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PRANC: PROGRAM FOR ANALYZING NONLINEAR CIRCUITS

Purdue University

H. K. Thapar B. J. Leon



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UNCLASSIFIED ECURITY CLASSIFICATION OF THIS PAGE(When Date Entered) Finally, algorithms for adapting the Volterra series method for computer aided steady-state analysis of nonlinear circuits are described. A complete documentation of the program PRANC, which uses the Volterra series approach, is also contained in this report. Accession For NTL- St DDC TAB Untumounced Justification By. Dist 1 ÷ . L 1.12 01: UNCLASSIFIED SECURITY CLASSIFICATION OF THIT PAGE (When Data Entered)

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PREFACE

This effort was conducted by Purdue University under the sponsorship of the Rome Air Development Center Post-Doctoral Program. Mr. Jon Valente of RADC was the task project engineer and provided overall technical direction and guidance. Prof. B. J. Leon directed this research and the preparation of this report at Purdue University. The authors of the report are B. J. Leon and H. K. Thapar.

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This document is the final report for Task 7 of Purdue University's Subcontract from Clarkson College of Technology. The task was to "Develop and Apply Symbolic Methods to the Volterra Series Approach to Nonlinear Circuit Analysis."

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CHAPTER 1

INTRODUCTION

1-1. Statement of the Objectives

In the analysis of nonlinear systems, two main classes of solutions are generally sought: 1) transient, and 2) steady state. The basic goal of this investigation is to obtain the sinusoidal steady-state solution of nonlinear circuits via the Volterra series method [1-14].

The most commonly used present-day approach for analyzing nonlinear systems is numerical integration [20]. The nonlinear differential equations are integrated from some initial time, t_0 , to some final time, t_f . When the sinusoidal steady-state response is sought, the value of t_f chosen is usually large to insure that all transients have been eliminated. A subsequent fast Fourier analysis yields the frequency components of the output response. A more efficient method for obtaining the sinusoidal steady-state response is to pose the analysis problem as a two-point boundary value problem and then apply Newton's method [20]. This approach, however, allows for only single frequency inputs.

The problems involved in the numerical integration method are well known [20]. These problems notwithstanding, there are other inefficiencies. When one is solely interested in the steady-state response, the computation expended in reaching t_f is a waste. This inefficiency grows as the poles of the linearized system move close to the imaginary axis, as is often the case in many quasi-linear communication circuits.

Other methods such as the harmonic balance or the describing function method are seldom used, simply because the assumption behind these methods render them undependable. The Picard iteration method [14] is often used in nonlinear systems analysis. This method also has limitations when used for computer-aided analysis, particularly when multi-tone inputs are present.

The fundamental intent behind this report is to examine the computational aspect of the Volterra series when used for the steady-state analysis of circuits with multiple nonlinearities and multiple multi-tone input sources. A basic algorithm for adapting this method for computer-aided analysis is developed. Its implementation as a digital computer program, entitled PRANC (<u>Program for Analyzing Nonlinear Circuits</u>), is also included in this report.

1-2. Organization of the Report

After this introductory chapter, this report contains the following five chapters.

Chapter 2, entitled "Volterra Series Method", discusses the analysis method which forms the basis of this investigation. A systematic approach for system characterization in the transform domain is developed. The determination of the sinusoidal steady-state response for multi-tone inputs from the system characterization is also developed.

Chapter 3 considers the computational aspect of the Volterra series method. An algorithm, which uses semi-symbolic analysis [20], is developed for the efficient implementation of this method on a digital computer. An overview of PRANC is also presented in this chapter.

Chapter 4 provides the User's guide for PRANC. Several examples to il-

Chapter 5 contains the Programmer's guide for PRANC. Each sub-program Listing, together with its functions, is documented in this chapter.

Finally, Chapter 6 is reserved for some concluding remarks.

CHAPTER 2

VOLTERRA SERIES METHOD

2-1. Introduction

Nonlinear systems that admit a Volterra series description are completely characterized by their nonlinear impulse response functions or the generalized transfer functions, which are the multi-dimensional transforms of the nonlinear impulse response functions. Thus, any analysis of nonlinear systems via the Volterra series method will entail the determination of either one of these functions.

The method for determining the generalized transfer functions given in [13] will be presented here. This method relies on the application of multi-dimensional transforms to a set of differential equations. In section 2-2 the multi-dimensional transform theory is introduced, along with the application of the theory to specific examples which will be subsequently used in deriving the generalized transfer functions. In section 2-3 the generalized transfer functions for an r-th order scalar nonlinear differential equation are obtained. Section 2-4 is devoted to the determination of the nonlinear transfer functions of a general multiple-node, multiplenonlinearity circuit with a single input. The case of multiple input sources is treated in section 2-5. Section 2-6 shows the relationship between the terms in the sinusoidal steady-state response and the generalized transfer functions.

2-2. Multi-dimensional Transforms

The Laplace transform pair of a one-dimensional function, f(t), is:

$$F(s) = \int_{-\infty}^{\infty} f(t) e^{-st} dt \qquad (2-1)$$

and

$$f(t) = \frac{1}{(2\pi j)} \int_{\sigma-j\infty}^{\sigma+j\infty} F(s) e^{st} ds \qquad (2-2)$$

For a multi-variable function, $f(t_1, t_2, \dots, t_n)$, the corresponding multidimensional transform [15] is:

$$F(s_1, s_2, \dots, s_n) = \int \cdots \int f(t_1, t_2, \dots, t_n) exp(-s_1 t_1 - \cdots - s_n t_n) dt_1 \cdots dt_n$$
(2-3)
n-fold

and

$$f(t_{1},...,t_{n}) = \frac{1}{(2\pi j)^{n} n - fold} \int \cdots \int F(s_{1},...,s_{n}) \exp(s_{1}t_{1} + \cdots + s_{n}t_{n}) ds_{1}...ds_{n}$$
(2-4)

$$f(t_1, \dots, t_n) \leftrightarrow F(s_1, \dots, s_n) \tag{2-5}$$

Before proceeding further, we make the following notational definitions:

$$F(s_{1}, s_{2}, \dots, s_{n}) = \ell[f(t_{1}, t_{2}, \dots, t_{n})]$$
(2-6)

and

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$$f(t_{1},t_{2},...,t_{n}) = \ell^{-1}[F(s_{1},s_{2},...,s_{n})]$$
(2-7)

Whether we use Fourier transform or Laplace transform in eqns. (2-3) and (2-4) depends on the contours of integration and values of s_1, s_2, \ldots, s_n . The importance of the region of convergence when dealing with unstable and non-causal linear systems is well known. Here we assume that the systems under consideration are causal; that is, the Volterra kernels $h_n(t_1,t_2,...,t_n) = 0$, for $t_1,t_2,...,t_n \leq 0$. Also, in general, we are concerned with functions (or generalized functions) whose region of convergence includes the imaginary axis in each variable, so that the Fourier transform is included in our definitions.

It should also be noted that most of the properties of the onedimensional transform (linear case) carry over to the multi-dimensional case. The validity of this statement can be checked elsewhere [5].

It is often desirable to express the multi-variable function, $f(t_1,t_2,...,t_n)$, as a simple function of time, f(t), and vice versa. If all t_i 's are restricted to be identical so that $t = t_1 = t_2 = \cdots = t_n$, then $f(t_1,t_2,...,t_n)$ becomes f(t). Thus, in the two variable case, f(t) can be obtained from $f(t_1,t_2)$ by evaluating $f(t_1,t_2)$ along the 45° line $t_1 = t_2$. Similarly, if we plot $f(t_1,t_2,t_3)$ in a three-dimensional space, then, to obtain f(t), we are only interested in $f(t_1,t_2,t_3)$ along the line $t_1 = t_2 = t_3$. The idea of converting a nonlinear function of one variable t into a product of linear multi-variable functions will be used repeatedly in the sequel. One must, however, bear in mind that the ultimate goal is to obtain the solution of the differential equation as a function of time, t, and that the introduction of t_1,t_2 , etc. are merely for mathematical manipulations.

We now apply multi-dimensional transforms to some specific cases which will be subsequently used in sections (2-3) and (2-4).

2-2.1 <u>Volterra Series</u>: The Volterra series relates the system input x(t) to the system output y(t) as follows*:

*Unless otherwise stated, all limits of integration are between 0 and ∞ in our discussion here.

$$y(t) = \sum_{n=1}^{\infty} \int \cdots \int_{n-fold} h_n(\tau_1, \dots, \tau_n) \prod_{i=1}^n x(t-\tau_i) d\tau_i$$

$$= \sum_{n=1}^{\infty} y_{n}(t)$$
 (2-8)

where

$$y_{n}(t) = \int \cdots \int_{n-fold} h_{n}(\tau_{1}, \dots, \tau_{n}) \prod_{i=1}^{n} x(t-\tau_{i}) d\tau_{i}$$
(2-9)

Introducing dummy variables t_1, t_2, \dots, t_n in eqn. (2-9) we can write $y_n(t)$ as:

$$y_{n}(t) = y_{n}(t_{1}, t_{2}, \dots, t_{n})|_{t_{1}=t_{2}=\dots=t_{n}=t}$$

$$= \int \cdots \int_{n-fold} h_n(\tau_1, \dots, \tau_n) \prod_{i=1}^n x(t_i - \tau_i) d\tau_i$$
(2-10)

Taking the n-dimensional transforms of eqn. (2-10), we get:

$$Y_n(s_1,\ldots,s_n) = \ell [Y_n(t_1,\ldots,t_n)]$$

$$= \int \cdots \int_{2n-fold} h_n(\tau_1, \tau_2, \dots, \tau_n) \prod_{i=1}^n x(t_i - \tau_i) e^{-s_i t_i} d\tau_i dt_i (2-11)$$

Defining $t_n - \tau_n = \sigma_n$, $t_{n-1} - \tau_{n-1} = \sigma_{n-1}$, $t_1 - \tau_1 = \sigma_1$, and therefore: $t_n = \sigma_n + \tau_n$, $t_{n-1} = \sigma_{n-1} + \tau_{n-1}$, $t_1 = \sigma_1 + \tau_1$; $d\sigma_n = dt_n$, $d\sigma_{n-1} = dt_{n-1}$, $d\sigma_1 = dt_1$. Substituting these quantities in eqn. (2-11) and performing the 2n-fold integrations with respect to τ_i and 6 σ_i, gives

$$Y_n(s_1,...,s_n) = H_n(s_1,...,s_n) \prod_{i=1}^n X(s_i)$$
 (2-12)

where $H_n(s_1, \dots, s_n)$ and $X(s_i)$ are the transforms of $h_n(t_1, t_2, \dots, t_n)$ and $x(t_i)$ respectively. Therefore the transform domain description of eqn. (2-8) becomes:

$$Y(s_1, s_2, \dots, s_n) = \sum_{n=1}^{\infty} H_n(s_1, \dots, s_n) = \prod_{i=1}^{n} X(s_i)$$
 (2-13)

If the input x(t) is a delta function, then eqns. (2-12) and (2-13) reduce, respectively, to:

$$Y_n(s_1,...,s_n) = H_n(s_1,s_2,...,s_n)$$
 (2-14)

and

$$Y(s_{1},...,s_{n}) = \sum_{n=1}^{\infty} H_{n}(s_{1},...,s_{n})$$
 (2-15)

Equations (2-12) through (2-14) will be used repeatedly in section (2-3).

2-2.2 <u>Nonlinear Terms</u>. The characteristics of nonlinear elements encountered in many nonlinear dynamical systems can be represented over any finite range by a polynomial. This gives rise to nonlinear differential equations with polynomial type nonlinear terms. When such elements are used in a system, the equilibrium equations contain integrals and derivatives of the polynomials. We can apply multi-dimensional transforms to these nonlinear terms by first converting an nth power to an n-fold product of terms with different domains. More detail on these derivatives is given in [13]. $\underline{y^{n}(t)}$ Term: Consider an n-dimensional time space with variables t_{i} , i=1,2,...,n. From the single variable function y(t) define an n-variable functional $y(t_{1},t_{2},...,t_{n}) = \prod_{i=1}^{n} y(t_{i})$. Then i=1

$$y^{n}(t) = y(t_{1}, t_{2}, \dots, t_{n}) \quad \forall t_{i} = t$$
 (2-16)

and

$$Y(s_{1},...,s_{n}) = \prod_{i=1}^{n} Y(s_{i})$$
 (2-17)

$$\frac{d}{dt} \underline{y^{n}(t)} \underline{\text{Term}}:$$

$$\frac{d}{dt} y^{n}(t) = \frac{d}{dt} y^{(t_{1}, \dots, t_{n})} t_{1} = t_{2} = \dots = t_{n} = t^{7}$$
(2-18)

$$f(s_1, s_2, \dots, s_n) = \pounds \sum_{s=1}^n \frac{\partial}{\partial t_s} y(t_1, \dots, t_n) \frac{dt_s}{dt}$$

= $(s_1 + s_2 + \dots + s_n)Y(s_1)\dotsY(s_n)$ (2-19)

 $\int y^{n}(t) dt$ Term:

$$\int y^{n}(t) dt = \int y_{n}(\tau_{1} - t, \tau_{2} - t, \dots, \tau_{n} - t) dt$$
 (2-20)

Letting $\tau_i = t = t_i$, and taking the transform of eqn. (2-20), we get

$$Y(s_1, s_2, \dots, s_n) = Y_n(s_1, \dots, s_n)/(s_1+s_2+\dots+s_n)$$
 (2-21)

$$= \left[\frac{1}{s_{1}+s_{2}+\cdots+s_{n}}\right]_{i=1}^{n} Y(s_{i})$$
(2-22)

The general forms in eqns. (2-12), (2-19) and (2-27) will be used in sections (2-3) and (2-4). The salient feature in each of these equations is how an nth degree polynomial function in the time-domain is represented by the nth-order product of the transform of the function in the transform domain. It is this product structure which, analogous to the case of linear system analysis, makes the analysis of nonlinear systems easier via the transform-domain approach.

2-3. A Nonlinear Differential Equation:

In this section, we present a method, based on applying the multidimensional transforms to nonlinear differential equations, to determine the response of a nonlinear system with a functional power series type of nonlinearity. The nonlinear differential equation considered is the following:

$$L_1[y(t)] + L_2[\sum_{n=2}^{N} a_n y^n(t)] = x(t)$$
 (2-23)

where x(t) and y(t) are system input and output, respectively, L_1 is a linear differential operator:

$$L_{1}[\cdot] = \sum_{r=0dt}^{R} \frac{d^{r}}{r} [\cdot]$$
(2-24)

and L_2 is $\frac{d}{dt}$, \int , or a constant, or a sum of these operators. It should be noted that the linear operator, L_2 , operates on a polynomial function of y(t).

We now present an approach whereby the nonlinear differential equation (2-23) is solved by a bootstrapping operation by first dissolving it into a set of linear differential equations with nonlinear inputs. Multidimensional transforms are then applied to these new equations to obtain the Volterra series solution.

There are many different methods of rendering a nonlinear differential equation into a sequence of linear differential equations involving successively higher order outputs with known nonlinear input terms. We use the approach outlined in [12].

Assume that the input in eqn. (2-23) is of the form

$$x(t) = \varepsilon_V(t) \tag{2-25}$$

The dummy variable ϵ helps to keep track of the order of the terms: a term with coefficient ϵ^n signifies an nth order term. This can be seen easily by substituting eqn. (2-25) in eqn. (2-9), which yields:

$$y_{n}(t) = \varepsilon^{n} \int \cdots \int h_{n}(\tau_{1}, \dots, \tau_{n}) \prod_{i=1}^{n} v(t - \tau_{i}) d\tau_{i}$$
(2-26)

Let us assume that r(t) is the response to the input v(t) in eqn (2-23). Then, according to the Volterra series expansion, as per eqn. (2-8) and (2-9), the n-th order response is:

$$r_{n}(t) = \int \dots \int h_{n}(\tau_{1}, \dots, \tau_{n}) \prod_{i=1}^{n} v(t-\tau_{i}) d\tau_{i}$$
(2-27)

Comparing (2-27) and (2-26), we obtain the following relationships:

$$y_n(t) = \varepsilon^n r_n(t)$$
 (2-28)

and therefore, as per eqn. (2-8),

$$y(t) = \sum_{n=1}^{\infty} y_n(t) = \sum_{n=1}^{\infty} e^n r_n(t)$$
 (2-29)

We now have two differential equations which relate r(t) and v(t). First, equation (2-23) can be re-written as:

$$L_{1}[r(t)] + L_{2}[\sum_{n=2}^{N} a_{n}r^{n}(t)] = v(t)$$
 (2-30)

Second, after substituting eqn. (2-29) into (2-23), we get:

$$L_{1}\left[\sum_{n=1}^{\infty} \epsilon^{n} r_{n}(t)\right] + L_{2}\left[\sum_{j=2}^{N} (a_{j} \sum_{n=1}^{\infty} \epsilon^{n} r_{n}(t))^{j}\right] = \epsilon v(t)$$
 (2-31)

Thus in order to solve eqn. (2-23), we can solve eqn. (2-31) for $r_n(t)$, n = 1,2,... and substitute in eqn. (2-29) to solve for y(t) after setting $\varepsilon = 1$. Setting $\varepsilon = 1$ implies that x(t) = v(t), and therefore $y(t) = r(t) = \sum_{n=1}^{\infty} r_n(t)$. The introduction of ε is a mathematical artifice which helps to equate coefficients of ε^n on both sides of eqn. (2-31), thereby yielding linear differential equations (involving successively higher order outputs) with non-linear inputs.

To solve for $r_1(t)$, the linear system response, we equate coefficients of ϵ^1 on both sides of eqn. (2-31), thus yielding the following equation:

$$L_1[r_1(t)] = v(t)$$
 (2-32)

Similarly we equate coefficients of ε^2 , ε^3 , ε^4 , ε^5 , and so on, on both sides of eqn. (2-31) to obtain the following equations:

$$L_{1}[r_{2}(t)] + L_{2}[a_{2}r_{1}^{2}(t)] = 0$$
 (2-33)

$$L_1[r_3(t)] + L_2[2a_2r_1(t)r_2(t) + a_3r_1^3(t)] = 0$$
 (2-34)

$$L_1[r_4(t)] + L_2[a_2(2r_1(t)r_3(t) + r_2^2(t)) + 3a_3r_1^2(t)r_2(t)]$$

$$+ a_4 r_1^4(t) = 0$$
 (2-35)

$$L_{1}[r_{5}(t)] + L_{2}[2a_{2}r_{1}(t)r_{4}(t) + a_{3}(3r_{1}^{2}(t)r_{3}(t) + 3r_{1}(t)r_{2}^{2}(t)) + 4a_{4}r_{1}^{3}(t)r_{2}(t) + a_{5}r_{1}^{5}(t)] = 0 \qquad (2-36)$$

To solve for the generalized transfer functions of eqn. (2-30), we take the 1-dimensional transform of eqn. (2-32) and obtain:

$$L_1(s_1)R_1(s_1) = V(s_1)$$
 (2-37)

If $v(t) = \sigma(t)$, then $V(s_1) = 1$, and therefore, according to eqn. (2-14), we have

$$R_1(s_1) = H_1(s_1) = \frac{1}{L_1(s_1)}$$
 (2-38)

To solve for the second-order transfer functions, $H_2(s_1,s_2)$, we extend the second term of eqn. (2-33) to a two dimensional domain. Since the physical system is not defined when $t_1 \neq t_2$ we can assume that the extension of eqn. (2-33) holds for all t_1 and t_2 . Transforming via eqn. (2-17) gives

$$L_{1}(s_{1}+s_{2})R_{2}(s_{1},s_{2}) + a_{2}L_{2}(s_{1}+s_{2})R_{1}(s_{1})R_{1}(s_{2}) = 0$$
(2-39)

Using (2-14) and (2-38) in eqn. (2-39), we obtain

$$R_{2}(s_{1},s_{2}) = H_{2}(s_{1},s_{2}) = -\frac{a_{2}L_{2}(s_{1}+s_{2})H_{1}(s_{1})H_{1}(s_{2})}{L_{1}(s_{1}+s_{2})}$$
(2-40)

For R_3 and higher terms we find that the order of variables t_1 , t_2 , t_3 seems important. Physically this should not be. We can symmetrize by averaging. That is, we sum each of the nth order transfer function over all permutations of its arguments and divide by the number of components in the sum. We use an overbar to represent the symmetrized function.

$$L_1(s_1+s_2+s_3)R_3(s_1,s_2,s_3) + L_2(s_1+s_2)[2a_2R_1(s_1)R_2(s_2,s_3)]$$

$$+ a_3 R_1(s_1) R_1(s_2) R_1(s_3) = 0$$
 (2-41)

Again, using eqns. (2-38), (2-40), and (2-14), we get

$$R_{3}(s_{1},s_{2},s_{3}) = H_{3}(s_{1},s_{2},s_{3}) = -L_{2}(s_{1}+s_{2}+s_{3})[2a_{2}H_{1}(s_{1})H_{2}(s_{2},s_{3})]$$

$$+ a_{3}H_{1}(s_{1})H_{1}(s_{2})H_{1}(s_{3})]/L_{1}(s_{1}+s_{2}+s_{3})$$
(2-42)

In a similar manner, we can derive by inspection:

$$H_4(s_1, s_2, s_3, s_4) = -L_2(\sum_{i=1}^{4} s_i) La_2(2H_1(s_1) H_3(s_2, s_3, s_4))$$

+
$$H_2(s_1,s_2)H_2(s_3,s_4)$$
 + $3a_3H_1(s_1)H_1(s_2)H_2(s_3,s_4)$

+
$$a_4 \sum_{i=1}^{4} H_1(s_i) J/L_1(\sum_{i=1}^{4} s_i)$$
 (2-43)

and

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$$H_{5}(s_{1},s_{2},s_{3},s_{4},s_{5}) = -L_{2}(\sum_{i=1}^{5} s_{i}) (2a_{2}H_{1}(s_{1})H_{4}(s_{2},s_{3},s_{4},s_{5}))$$

$$+ 3a_{3}(H_{1}(s_{1})H_{1}(s_{2})H_{3}(s_{3},s_{4},s_{5}))$$

$$+ H_{1}(s_{1})H_{2}(s_{2},s_{3}))H_{2}(s_{4},s_{5})$$

$$+ 4a_{4}H_{1}(s_{1})H_{1}(s_{2})H_{1}(s_{3})H_{2}(s_{4},s_{5}) + a_{5}\sum_{i=1}^{5} H_{1}(s_{i})]/L_{1}(\sum_{i=1}^{5} s_{i})(2-44)$$

The use of symmetric transfer functions is not merely for notational convenience, but is necessitated by the method we use for introducing the parameters t_1, t_2, \ldots , before taking the transforms. Consider a third order term $v_3(t)$ formed as the product of a first order term $v_1(t)$ and a second order $v_2(t)$. On the three dimensional (t_1, t_2, t_3) we could write $v_3(t_1,t_2,t_3)$ as $v_1(t_1)v_2(t_2,t_3)$, $v_1(t_2)v_2(t_1,t_3)$, or $v_1(t_3)v_2(t_1,t_2)$. The first term has transform: $V_1(s_1)V_2(s_2,s_3)$; the second term has: $V_1(s_2)V_2(s_1,s_3)$; and the third has transform: $V_1(s_3)V_2(s_1,s_2)$. When $V_2(\cdot,\cdot)$ is not symmetrical in its arguments, each transformed quantity above will yield a different value. Thus, it becomes necessary to use symmetric transfer functions when performing numerical computations to obtain the system response. It can be shown that the response is unchanged when symmetrized transfer functions are used. Since, in the final analysis we want value when t₁=t₂=t₃, we of $v_3(t_1,t_2,t_3)$ only may write the

 $v_1(t)v_2(t) = \frac{1}{3} [v_1(t_1)v_2(t_2,t_3) + v_1(t_2)v_2(t_1,t_3) + v_1(t_3)v_2(t_1,t_2)]$. This does not change the contribution due to $v_1(t)v_2(t)$ in the system response. In the remaining part of this report we will assume the generalized transfer functions to be symmetric in their arguments.

To conclude this sub-section, we summarize the approach for obtaining the generalized transfer functions of a nonlinear system and also comment on the important ramification of the method. By introducing a dummy variable in the nonlinear differential equation characterizing the system, a set of differential equations of the following form was obtained:

$$L[r_n(t)] + f(r_{n-1}(t)) = 0, n = 2,3,...$$
 (2-45)

where L is the linear system operator and f(*) is a nonlinear function of $r_{n-1}(t)$, $r_{n-2}(t)$,..., $r_1(t)$. $r_1(t)$ is the first-order response, which is simply the response of the linear system. The relationship in eqn. (2-45) is clearly a recursive one, and can be used to solve for $r_n(t)$ in terms of $r_{n-1}(t)$, $r_{n-2}(t)$, etc. This is done by first finding the n-dimensional transform of $f(r_{n-1}(t))$ as discussed above. We then use the transform of eqn. (2-44) to solve for $R_n(s_1,...,s_n)$, the nth-order transfer function when the input v(t) is an impulse. The transform of f(*) is done by inspection with the help of the results of section (2-2). The n-dimensional transform of $L[r_n(t)]$ is shown to be $L(s_1+s_2+...+s_n)R_n(s_1,s_2,...,s_n)$. With all this information, eqn. (2-45) is easily solved for the generalized transfer function.

2-4. Multiple-Node, Multiple-Nonlinearity Circuit Analysis

Many analysis and design problems in circuits and systems involve one or at most a few nonlinear elements in an otherwise linear time-invariant circuit or system. When a single nonlinear element is present, the dif-

ferential equation (2-23) and the material of section (2-2) will be adequate for analyzing the nonlinear circuit. For, in such a case, the linear circuit can be characterized by a convolution kernel (via the Thevenin or Norton Theorems) to give the overall Volterra integral equation [14], which can also be cast in a differential equation form, similar to eqn. (2-23).

However, when multiple nonlinear elements are imbedded in an otherwise linear time-invariant circuit, the analysis entails the solution of a <u>system</u> of nonlinear differential equations. The approach developed in section (2-2) for the scalar case is still applicable, but must be extended to solve the system of nonlinear differential equations.

The number of equations to be solved depends on the number and the type of nonlinear elements considered. When only independent type nonlinear elements are considered, the number of equations is less than or equal to the number of nonlinear elements (assuming that the output is across one of the nonlinear elements; otherwise, an extra equation relating the nonlinear element voltages (currents) and the output voltage (current) is needed to solve for the output). The nonlinear differential equations in such a case is again derived by obtaining the Thevenin (Norton) equivalent circuit (for the linear part of the nonlinear circuit) at each of the ports at which the nonlinear elements are present. When dependent type nonlinear elements are also allowed, the analysis becomes more complicated; for, in such a case, the controlling variables, which may be across a linear element, must be solved for and substituted in the differential equation for the nonlinear element.

Previous works [7,10-12] for determining the generalized voltage ratio transfer functions of lumped nonlinear circuits have applied the harmonic input method, to the nodal analysis. Our discussion in this section for

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solving multiple-node, multiple-nonlinearity circuits will be centered around the application of multi-dimensional transforms to a cutset type analysis. Thus, we will be solving for the generalized voltage ratio transfer functions. As we proceed with our discussion, it will become apparent that a cutset analysis approach is the most natural way of solving for the generalized voltage-ratio transfer functions. We now develop the procedure.

The first step in the analysis is to represent each nonlinear element by a polynomial expansion. Thus, in the distortion analysis of transistor amplifiers [7], the exponential type controlled sources in the Ebers-Moll model are first represented by a Taylor series expansion of the function about the quiescent point, thereby yielding a polynomial in terms of the incremental variables. The types of nonlinear elements, and their series representation, that are commonly encountered are:

1. No memory, independent nonlinearity (Nonlinear Resistor)

$$i = F(v) = \sum_{j=1}^{\infty} a_j v^j$$
 (2-46)

2. No memory, dependent nonlinearity

$$i = G(u,v) = \sum_{j=0}^{\infty} \sum_{k=0}^{\infty} a_{jk} u^{j} v^{k} , a_{00} = 0$$
 (2-47)

3. Capacitive, independent nonlinearity

$$i = \frac{d}{dt}Q(v) = \frac{d}{dt}\sum_{j=1}^{\infty} a_j v^j$$
(2-48)

4. Inductive, independent nonlinearity

$$i = \int_{-\infty}^{t} \phi(v) dt = \int_{-\infty}^{t} \sum_{j=1}^{\infty} a_{j} v^{j} dt$$
 (2-49)

where

- $i \equiv$ incremental current through the element
- v = incremental controlling voltage
- u = incremental controlling voltage

The general procedure employed to solve for the nonlinear transfer functions of a single-input, single-output nonlinear circuit using the cutset analysis approach is illustrated in Fig. 2-1 by considering each of the four nonlinear element types mentioned above.

Consider the nonlinear circuit N, shown in Fig. 2-1(a), containing a nonlinear resistor, a nonlinear dependent source, a nonlinear capacitor, and a nonlinear inductor, where each nonlinear element is voltage controlled. The procedure begins by identifying all the nonlinear elements, as shown in Fig. 2-1(b). We note that the four nonlinear elements depend on six voltages. The next step is to lump the linear parts of the nonlinear elements with the existing linear network to form the <u>augmented linear network</u>. The square, cubic, quartic, etc. terms of the nonlinearity are treated as non-linear current sources, indicated by i_k^n , meaning the nth order current source at port k. Since the dependent source, $g(v_5, v_6)$, depends on voltages v_5 and v_6 , we also extract these as ports. Thus, altogether we end up with an 8-port linear network, as shown in Fig. 2-1(c).



Figure 2-1. Steps in Nonlinear Circuit Analysis using Volterra Series.





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The output variables to be found are the voltages at these eight ports. The augmented linear network is denoted by N' in Fig. 2-1(c). To solve for the voltage vector $\underline{v} = [v_1 \ v_2 \ v_3 \ \cdots \ v_8]$, we immediately recognize that the branches across these voltage variables must be selected as part of the tree [20]. Clearly, some of the other branches in the augmented linear network may also appear as part of the tree. These will then appear as voltage variables in the cutset equations for the augmented linear network. Since there is no need for these additional variables, we can reduce the dimensionality of our equations by a systematic elimination of these unwanted variables. In the case under consideration, we should be left with only the vector $\underline{v} = [v_1 \ v_2 \ \cdots \ v_8]$ as the unknown vector. Each of these 8 ports will have a set of transfer functions of order 1 to n associated with it. Our task here is to solve for these transfer functions.

At this point, we make the following general notational definitions:

$$\underline{H}_{k}^{(s_{1},s_{2},...,s_{k})} = \begin{bmatrix} H_{k}^{1}(s_{1},...,s_{k}) \\ H_{k}^{2}(s_{1},...,s_{k}) \\ \vdots \\ \vdots \\ \vdots \\ H_{k}^{m}(s_{1},s_{2},...,s_{k}) \end{bmatrix}$$
(2-50)

where

 $H_k^j \equiv kth$ order nonlinear transfer function from the input to the jth port; m = 8 in our example here.

$$\underline{v}^{(t)} = [v_1(t) \ v_2(t) \ \dots \ v_m(t)]^T$$
(2-51)

where $v_i \equiv voltage$ at the ith port

The cutset equations for the m-port nonlinear network can be written as:

$$\frac{Y(p)_{\underline{v}} + F(v)}{[v_g/z_g(p)][1 \ 0 \ 0 \ \dots \ 0]^T} =$$

$$(2-52)$$

(2-52)

where

$$p \equiv differential operator, \frac{d}{dt}$$

Y(p) Reduced admittance matrix for the p-port augmented linear network Ξ

- vector composed of all nonlinear currents through the zero memory F(v)Ξ independent nonlinearity
- $G(u,v) \equiv vector composed of all nonlinear currents through the zero memory$ dependent nonlinearities

 $Q(v) \equiv$ vector composed of all nonlinear currents through the nonlinear capacitive nonlinearities

= vector composed of all nonlinear currents through the nonlinear φ(v) inductive elements.

z_(p) = source impedance Since the linear parts of the functions $F(\cdot)$, $G(\cdot)$, $Q(\cdot)$, and $\phi(\cdot)$ in eqn. (2-46) through (2-49) have been lumped together with the linear part of the network, the general form of these functions will be as follows:

$$\underline{Z}(\underline{v}) = \underline{Z}_{2}(\underline{v}) + \underline{Z}_{3}(\underline{v}) + \underline{Z}_{4}(\underline{v}) + \cdots$$
(2-53)

where

 $Z_2(\underline{v})$ is a quadratic function of \underline{v} $Z_3(\underline{v})$ is a cubic function of \underline{v} $Z_4(\underline{v})$ is a quartic function of \underline{v} ...

<u>Z(*)</u> being <u>F(*)</u>, <u>G(*)</u>, <u>Q(*)</u>, or ϕ (*). Thus, eqn. (2-53) can be re-written as:

$$Y_{(p)\underline{v}} = \frac{1}{z_{g}(p)} \begin{bmatrix} v_{g}(t) \\ 0 \\ 0 \\ \cdot \\ \cdot \\ 0 \\ 0 \end{bmatrix} - \frac{i_{k}(t)}{k} (t) , k \ge 2$$
(2-54)

where $\underline{i}_{k}(t)$ denotes vectors of $2\underline{nd}$ and higher order current sources due to $\underline{F(v)}$, $\underline{G(u,v)}$, $pQ(\underline{v})$, and $\frac{1}{p}\phi(\underline{v})$. The mathematical artifice used in section (2-2) could have been applied here also to obtain the form of all the non-linear current source terms, $\underline{i}_{k}(t)$. For the sake of brevity, we will not use that approach here, but simply use the results of section (2-2) to identify the different order current sources due to different nonlinearities. These are summarized in Table 2-1, where $v^{i}(t)$ denotes the ith order response voltage v(t), which control the nonlinear element characteristics.

Table 2-1. Nonlinear Current Sources in multiple-node, multiple-nonlinearity circuit analysis.

Nonlinear Resistor,
$$F(v)$$
:

$$k = 2: a_{2} [v^{1}]^{2}$$

$$k = 3: 2a_{2} [v^{1}v^{2}] + a_{3} [v^{1}]^{3}$$

$$k = 4: a_{2} [2v^{1}v^{3} + (v^{2})^{2}] + 3a_{3} [v^{1}]^{2}v^{2} + a_{4} [v^{1}]^{4}$$

$$\underline{Nonlinear Dependent Nonlinearity G(u,v):}$$

$$k = 2: a_{20} [u^{1}]^{2} + a_{02} [v^{1}]^{2} + a_{11} u^{1}v^{1}$$

$$k = 3: a_{30} [u^{1}]^{3} + a_{03} [v^{1}]^{3} + a_{21} [u^{1}]^{2}v^{1} + a_{12} u^{1} [v^{1}]^{2} + 2a_{20} u^{1}u^{2} + 2a_{02} v^{1}v^{2} + a_{11} [u^{1}v^{2} + u^{2}v^{1}]$$

$$k = 4: a_{40} [u^{1}]^{4} + a_{04} [v^{1}]^{4} + a_{13} u^{1} [v^{1}]^{3} + a_{22} [u^{1}]^{2} [v^{1}]^{2} + a_{12} (2u^{1}u^{3} + (u^{2})^{2}) + a_{11} (u^{3}v^{1} + u^{1}v^{3} + u^{2}v^{2}) + a_{02} (2v^{1}v^{3} + (v^{2})^{2}) + a_{03} [v^{1}]^{2}v^{2} + a_{03} [v^{1}]^{2}v^{2} + a_{21} ([u^{1}]^{2}v^{2} + 2u^{1}u^{2}v^{1}) + a_{12} (u^{2} [v^{1}]^{2} + 2u^{1}v^{1}v^{2})$$

Nonlinear Capacitive Nonlinearity pQ(v):

$$k = 2: \quad a_2 p [v^1]^2$$

$$k = 3: \quad 2a_2 p [v^1 v^2] + a_3 p [v^1]^3$$

$$k = 4: \quad a_2 p (2v^1 v^3 + [v^2]^2) + 3a_3 p [v^1]^2 v^2 + a_4 p [v^1]^4$$



Nonlinear Inductive Nonlinearity, $[1/p]\phi(v)$

$$k = 2: \frac{a_2}{p} [v^1]^2$$

$$k = 3: \frac{2a_2}{p} [v^1v^2]_{+\frac{a_3}{p}} [v^1]^3$$

$$k = 4: \frac{a_2}{p} (2v^1v^3 + [v^2]^2)_{+\frac{3a_3}{p}} [v^1]^2v^2_{+\frac{a_4}{p}} [v^1]^4$$

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We observe that the nonlinear current source terms in Table 2-1 are similar to the nonlinear terms whose transforms were derived in section 2-2, except for the nonlinear dependent source terms, which are functions of two controlling voltages u and v. The form of the transforms of the nonlinear dependent source will, however, be similar to the other nonlinearity types. These can again be written by inspection. For example,

$$a_{20}[u^{1}(t)]^{2} + a_{20}u^{1}(t_{1})u^{1}(t_{2}) \leftrightarrow a_{20}U(s_{1})U(s_{2})$$
 (2-55)

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$$a_{11}u^{1}(t)v^{1}(t) \rightarrow a_{11}u^{1}(t_{1})v^{1}(t_{2}) \leftrightarrow a_{11}U(s_{1})V(s_{2})$$
 (2-56)

$$a_{20}u^{1}(t)v^{2}(t) + a_{20}u^{1}(t_{1})v^{2}(t_{2}t_{3}) + a_{20}u^{1}(s_{1})v(s_{2}s_{3})$$
 (2-57)

Recall the one way arrow goes backwards only when $t_1 = t_2 = t_3$.

We also note that a k-th order current source term in Table 2-1 depends on responses of order less than k, which implies that, in order to calculate a transfer function of order k, we need to determine the transfer function up to order (k-1).

The first order transfer function can be solved for easily. It is simply the linear circuit response. Therefore,

$$Y(p)y(t) = i_1(t)$$
 (2-58)

For a single input system, $\underline{i}_1(t) = 1/z_g [v_g(t) \ 0 \ 0 \ ... \ 0]^T$, where $v_g(t)$ is the source voltage. Taking the transform of eqn. (2-58), and assuming that the input source to be an impulse function, we get:

$$\underline{v}^{1}(s_{1}) = \underline{H}_{1}(s_{1}) = 1/z_{g} [\underline{v}(s_{1})]^{-1} [1 \ 0 \ 0 \ \dots \ 0]^{T}$$
(2-59)

where $\underline{H}_1(s_1)$ was defined in eqn. (2-50).

The equation for obtaining the second-order response, as per eqn. (2-54), is the following:

$$Y(p) v^{(2)}(t) = - i_{2}(t)$$
 (2-60)

Since the input to the nonlinear circuit is assumed to be an impulse function, the transform of eqn. (2-60), after using eqn. (2-14), is:

$$\underbrace{Y}(s_1 + s_2) \underbrace{H}_2(s_1, s_2) = - \underline{I}_2(s_1, s_2)$$
 (2-61)

The elements of vector $\underline{I}_2(s_1,s_2)$ can be obtained by performing a twodimensional transform on the terms associated with k = 2 in Table 2-1. This operation, as indicated earlier, can be carried out by inspection. Thus, we have

$$\underline{H}_{2}(s_{1},s_{2}) = - [\underline{Y}(s_{1}+s_{2})]^{-1} \underline{I}_{2}(s_{1},s_{2})$$
(2-62)

Likewise we can solve for $\underline{H}_3(s_1,s_2,s_3)$. In general, we solve for the nth order transfer function using eqn. (2-63):

$$\underline{H}_{n}(s_{1},s_{2},\ldots,s_{n}) = [\underline{Y}(\sum_{i=1}^{n} s_{i})]^{-1} \underline{I}_{n}(s_{1},\ldots,s_{n})$$
(2-63)

We observe a striking similarity between eqn. (2-63) and the equations for nodal or cutset analysis encountered in linear circuit analysis. A little thought would show that the process of solving eqn. (2-63) is identical to solving the linear circuit in Fig. 2-2. We have nonlinear current sources as inputs to the augmented linear circuit. A k-th order vector of transfer functions is obtained by exciting the linear circuit by the kth order current sources. Just as in the case of linear systems, <u>superposition</u> can be applied here when a particular order response is determined from the


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lower order responses. That is, a k-th order response can be obtained by applying the k-th order current sources one-by-one at each of the ports ar then summing up the responses. It is important to note, however, that the complete responses of order up to (k-1) must be determined before we can obtain the kth order response by superposition. It is also noted that the illustration of Fig. 2-2 is for pedagogic purpose and that the nonlinear current sources are not physically present in the circuit under consideration.

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2-5. Multiple Input Circuit Analysis

Much of the foregoing discussion has been concerned with the analysis of nonlinear circuits with single inputs. However, many applications of practical significance is nonlinear circuit analysis have multiple inputs. For example, in a receiver system, the mixer circuit has two inputs: 1) the message signal, and 2) the local oscillator signal. The transmitter again has nonlinear circuits with multiple inputs. The Volterra series method is especially well suited for the analysis of such circuits. In this section we discuss how the various order transfer functions change as a result of multiple inputs.

From the discussion in section 2-4, it should be apparent that the analysis of nonlinear circuits using the Volterra series method involves the repeated analysis of a linearized circuit. The fundamental relationship had the following form (see eqn. 2-54):

$$Y(p)\underline{v}(t) = \frac{1}{z_{g}(p)} \frac{i}{-1}(t) - \frac{i}{-2}(t) - \frac{i}{-3}(t) + \dots$$
(2-64)

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where $\underline{i}_{k}(t)$ is the k-th current source vector. For $k \ge 2$ the k-th order current source, depends on up to the (k-1) order voltage ratio transfer 29

functions as discussed above. It is injected at each of the pots at which the nonlinear elements are present, and is <u>due</u> entirely to the nonlinear characteristics of the nonlinearity. Furthermore, it is proportional to the k values of the circuit input multiplied together. Thus, the <u>number of</u> <u>elements in the vector $i_k(t)$, $k \ge 2$, remain unchanged when multiple inputs</u> are present; only the $i_1(t)$ vector is changed. Consider, for example, the two-input circuit of Fig. 2-3(a). Then, to solve for the first-order transfer function, we write the vector transform equation as:

$$\underline{Y}(s_1)\underline{V}(s_1) = \underline{I}_1(s_1)$$
 (2-65)

where

$$I_1(s_1) = [Y_{g1}(s_1)V_{g1}(s_1) Y_{g2}(s_1)V_{g2}(s_1) 0 \dots 0]^T$$
 (2-66)

and Y and <u>V</u> are as defined previously. The transfer function vector can be written as:

$$\frac{H_{1}(s_{1}) = H_{10}(s_{1}) + H_{01}(s_{1})$$
(2-67)

where

$$\underline{H}_{10}(s_1) = \begin{bmatrix} v^{(1)}(s_1) & v^{(2)}(s_1) \\ \hline v_{g1} & v_{g1} \end{bmatrix} \begin{bmatrix} v^{(2)}(s_1) & v^{p}(s_1) \\ \hline v_{g1} \end{bmatrix}^{\mathsf{T}} | v_{g2}^{=0}$$
(2-68)

and



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(b) Circuit for determining first-order transfer function.

Fig. 2-3. Multiple Input Nonlinear Circuit Analysis. 31





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$$\underline{H}_{01}(s_1) = \begin{bmatrix} v^{(1)}(s_1) & v^{(2)}(s_1) \\ v_{g2} & v_{g2} \end{bmatrix} \cdots \frac{v^{(p)}(s_1)}{v_{g1}} \end{bmatrix} \begin{bmatrix} T \\ v_{g1} \end{bmatrix}^{T}$$
(2-69)

where $V^{(i)}$ is the voltage at port i.

The second- and higher-order transfer function vectors are solved for by removing the given input sources and applying the fictitious nonlinear current sources across the ports at which the nonlinear elements are present. The vector transform equation for solving for the second-order transfer function is still given by:

$$\underline{H}_{2}(s_{1},s_{2}) = -[\underline{Y}(s_{1} + s_{2})]^{-1} [\underline{I}_{2}(s_{1},s_{2})]$$
(2-70)

where

$$\underline{I}_{2}(s_{1},s_{2}) = [I^{(1)}(s_{1},s_{2}) I^{(2)}(s_{1},s_{2}) \cdots I^{(p)}(s_{1},s_{2})] \qquad (2-71)$$

Depending on the nonlinearity type, the general form of $I^{(l)}(s_1,s_2)$, the second-order current source across port l, will be:

$$I_{2}^{(\ell)}(s_{1},s_{2}) = a_{2}H_{1}^{(\ell)}(s_{1})H_{1}^{(\ell)}(s_{2})$$
(2-72)

where $H_1^{(l)}(\cdot)$ is known from eqn. (2-67). The determination of the higherorder transfer functions is done similarly.

In summary, we note that the presence of multiple input sources in a nonlinear circuit does not drastically alter the procedure for determining the Volterra transfer functions. Only the structure of the first-order current source vector is changed as a result of multiple sources. This change is reflected in the values of the elements making up the second- and higher-order current source vectors, whose structure remains unchanged.

2-6. Sinusoidal Steady-State Analysis

In linear system theory, the sinusoidal steady-state response is intimately tied to the transfer function of the system. A similar result is found for higher order responses using the Volterra series method: an n-th order response at a particular frequency is directly related to the n-th order transfer function. In this section we develop this relationship.

If the harmonic input method [10-12] had been used in deriving the generalized transfer functions in the previous sections, the relationship between the n-th order steady state response and the n-th order transfer function would have been self-evident. But, since multi-dimensional transform theory was used to derive the generalized transfer functions, this relationship must be developed. We treat the specific case of n=2 in section 2-6.1 and then derive the general relationship in section 2-6.2.

2-6.1. Second-order Sinusoidal response:

The second-order output, according to the Volterra series, is given by:

$$y_{2}(t) = \int_{0}^{\infty} \int_{0}^{\infty} h_{2}(t-\tau_{1}, t-\tau_{2}) x(\tau_{1}) x(\tau_{2}) d\tau_{1} d\tau_{2}$$
(2-73)

Consider the input signal comprising two unit sinusoidal signals at frequencies ω_{a} and ω_{b} . The input $x(\tau)$ is therefore:

$$x(\tau) = \left[\frac{\exp(j\omega_{a}\tau) + \exp(-j\omega_{a}\tau)}{2}\right] + \left[\frac{\exp(j\omega_{b}\tau) + \exp(-j\omega_{b}\tau)}{2}\right]$$
(2-74)

Substituting eqn. (2-74) in (2-73), we have:

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$$Y_{2}(t) = \int_{0}^{\infty} \int_{0}^{\infty} h_{2}(t-\tau_{1}, t-\tau_{2}) \cdot \\ \cdot \left[\frac{\exp(j\omega_{a}\tau_{1}) + \exp(-j\omega_{a}\tau_{1})}{2} + \frac{\exp(j\omega_{b}\tau_{1}) + \exp(-j\omega_{b}\tau_{1})}{2} \right] \\ \cdot \left[\frac{\exp(j\omega_{a}\tau_{2}) + \exp(-j\omega_{a}\tau_{2})}{2} + \frac{\exp(j\omega_{b}\tau_{2}) + \exp(-j\omega_{b}\tau_{2})}{2} \right] \\ \cdot d\tau_{1}d\tau_{2}$$

$$(2-75)$$

Considering one cross term only,

$$\int_{0}^{\mu} \int_{0}^{h_{2}(t-\tau_{1},t-\tau_{2})} \frac{1}{4} \exp(j\omega_{a}\tau_{1}+j\omega_{b}\tau_{2})d\tau_{1}d\tau_{2}$$
(2-76)

and letting $\sigma_1 = t - \tau_1$ and $\sigma_2 = t - \tau_2$ and carrying out the integration yields,

$$\frac{1}{4} H_2(j\omega_a, j\omega_b) \exp[j(\omega_a + \omega_b)t]$$
(2-77)

Considering the other cross term similarly yields

$$\frac{1}{4} H_2(j_{\omega_b}, j_{\omega_a}) \exp[j(\omega_a + \omega_b)t]$$
(2-78)

However, if $H_2(s_1,s_2)$ is symmetrical in its arguments, as they are assumed to be in this report, then the terms in eqns. (2-77) and (2-78) are equal. The complex conjugate terms appear similarly. Hence, the output at frequency watwb is:

$$y(t)|_{\omega_{a}+\omega_{b}} = [H_{2}(j\omega_{a},j\omega_{b})|\cos[(\omega_{a}+\omega_{b})t + \theta_{a+b}]$$
(2-79)

The $2\omega_a$ or $2\omega_b$ term and their complex conjugates appear only once in eqn. (2-75); hence, their magnitude will be $\frac{1}{2}|H_2(j\omega_a,j\omega_a)|$ and $\frac{1}{2}|H_2(j\omega_b,j\omega_b)|$, respectively. If only one frequency input was present, the results would be similar. The second-order output would then be:

$$y_{2}(t) = |H_{2}(j\omega_{a}, -j\omega_{a})| + \frac{|H_{2}(j\omega_{a}, j\omega_{a})|}{2} \cos(2\omega_{a}t + \theta_{2a})$$
(2-80)

Thus, if we know $H_2(s_1,s_2)$, then the quantities in eqn. (2-80) can be easily evaluated. This is analogous to the case of linear systems, where the complex variable s is replaced by jw to compute the response at w.

If more than two-tones were present at the input, the second order response would be evaluated by taking all combinations of two frequencies at a time.

The response of the third and higher orders is similarly treated. We now present the general case.

2-6.2. General Sinusoidal Steady-State Analysis.

In this sub-section, we develop the relationship which can be applied directly to compute the sinusoidal steady-state response of a nonlinear system from its nonlinear transfer functions, which can be obtained by the method presented in section 2. The discussion here relies heavily on [10].

Consider a nonlinear system excited by the sum of K distinct tones; i.e., defining N = 2K, we have,

$$x(t) = \frac{1}{2} \sum_{i=1}^{N} A_{i} \exp(j \omega_{i} t)$$
 (2-81)

where w_i will include both positive and negative frequencies, and A_i for a negative frequency will be the complex conjugate of A_i for the positive fre-36 quency in order to have x(t) real. Then, the nth order output, $y_n(t)$, is given by:

$$y_n(t) = \int_{n-fold}^{\dots} h_n(\tau_1, \dots, \tau_n) \prod_{i=1}^n x(t-\tau_i) d\tau_i$$

$$= \int \cdots \int h_n(\tau_1, \dots, \tau_n) \frac{1}{2^n} \sum_{i=1}^n \sum_{k=1}^N A_k \exp[j\omega_k(t-\tau_i)] d\tau_i$$
(2-82)

Carrying out the product operation in eqn. (2-82), we get a function $y_n(t)$ containing Nⁿ terms, given by:

$$y_{n}(t) = \sum_{k_{1}=1}^{N} \cdots \sum_{k_{n}=1}^{N} \frac{1}{2^{n}} A_{k_{1}} \cdots A_{k_{n}} H_{n}(j_{\omega_{k_{1}}}, \dots, j_{\omega_{k_{n}}})$$

• exp[j($\omega_{k_{1}}$ + ... + $\omega_{k_{n}}$)t] (2-83)

Notice that in arriving at eqn. (2-83), we have performed the τ_i integration in eqn. (2-82), thus giving rise to the n-th order transfer function in eqn. (2-83). As the indices k_i are varied over the range 1 to N, many of the terms will be at the same frequency. The number of terms at various particular frequencies will vary according to what frequency combinations are taken. For example, in the case of n=2 in section 2-6.1, there were two cross frequency terms, while there was only one second harmonic (at $2\omega_a$) term. Similarly, for n=3, there are six terms in eqn. (2-83) at frequency $\omega_a + \omega_b + \omega_c$, three terms at $2\omega_a + \omega_b$, one term at $3\omega_a$, etc. The nonlinear transfer functions, which make up the coefficients of these frequency terms, differ only in their arguments. However, since the transfer functions are assumed to be symmetric, the coefficient of the output at frequency $\omega_a + \omega_b + \omega_c$ 37 (in the case of n=3) can be multiplied by 6. This obviates the need for taking all combinations to compute the output at $\omega_a + \omega_b + \omega_c$. Likewise we handle the case of other frequency combinations. With this insight, we can peek at the problem from a different perspective.

Let m_1, m_2, \dots, m_N be non-negative integers. Then, the number of terms at frequency $\omega_{\Sigma} = m_1 \omega_1 + m_2 \omega_2 + \dots + m_N \omega_N$ is equal to the number of ways of forming $m_1 \omega_1 + \dots + m_N \omega_N$. In the n-th order output spectrum to a multi-tone input, each term is evaluated by taking a distinct combination of n input tones at a time. To compute the n-th order output when the input frequencies are $\omega_1, \omega_2, \dots, \omega_N$, we must therefore restrict m_i in the following manner to compute ω_{Σ} :

$$m_1 + m_2 + \cdots + m_N = n$$
 (2~84)

Now the problem reduces to the following: find the number of ways in which n objects can be divided into N groups of which the first contains m_1 objects, the second m_2 objects, etc. The solution to this problem is given by the multi-nomial coefficient [22]:

$$C_{n,N} = \frac{n!}{m_1!m_2\cdots m_N!}$$
 (2-85)

By deriving eqn. (2-85), we have obviated the repetition of terms that is inherent in eqn. (2-83). An equivalent way of representing eqn. (2-83)through the use of eqn. (2-85) then becomes:

$$y_{n}(t) = \sum_{n \in N} c_{n \in N} \frac{A_{1}^{m_{1}} A_{2}^{m_{2}} \cdots A_{N}^{m_{N}}}{2^{n}}$$

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• $exp[j(m_{1}\omega_{1} + ... + m_{N}\omega_{N})t]$ (2-86)

Since $y_n(t)$ is real, eqn. (2-86) also contains the complex conjugate terms. Thus, the coefficient of the sinusoidal term at frequency $m_1 \omega_1 + \dots + m_N \omega_N$ in the n-th order output is given by:

$$C_{n,N} \xrightarrow{A_1^{m_1}A_2^{m_2}\cdots A_N^{m_N}}_{2^{n-1}} H_n(j\omega_1, \dots, j\omega_2, \dots, j\omega_N, \dots, j\omega_N) \qquad (2-87)$$

In computing the entire n-th order response in eqn. (2-86), we take all distinguishable combinations of m_i satisfying eq. 82-84). According to [10] there are

$$S_{n,N} = \begin{pmatrix} n+N-1 \\ n \end{pmatrix} = \frac{(n+N-1)!}{n!(N-1)!}$$
(2-88)

such combinations.

Equation (2-86) is the fundamental relationship between the n-th order output and the n-th order transfer function. At first glance, the evaluation of this equation appears to be a formidable task. But, after some thought, one finds that this is not such a difficult task after all. We, however, defer the discussion of this till section 4.

We now illustrate the use of eqn. (2-87). We assume that the nonlinear transfer functions are known. The case for n=2 can be easily verified from the discussion in section 2-6.1. For a two-tone input at ω_1 and ω_2 and n=3, we have the following cases:

(a) The output at w_1 and w_2 have the following amplitudes, respectively:

$$y_{3}(t)|_{\omega_{1}} = \frac{3!|A_{2}|^{2}A_{1}}{(4)!!!!!!} |H_{3}(j\omega_{1}, -j\omega_{2}, j\omega_{2})|$$
(2-89)

$$y_{3}(t)|_{\omega_{2}} = \frac{3!A_{2}|A_{1}|^{2}}{(4)1!1!1!} |H_{3}(j\omega_{1},-j\omega_{1},j\omega_{2})| \qquad (2-90)$$

(b) The output at $2\omega_1 + \omega_2$ has the following magnitude:

$$y_{3}(t)|_{2\omega_{1}+\omega_{2}} = \frac{3!A_{1}^{2}A_{2}}{(4)2!1!} |H_{3}(j\omega_{1}, j\omega_{1}, j\omega_{2})|$$
(2-91)

(c) The output at $3\omega_1$ has the following magnitude:

$$y_{3}(t)|_{3v_{1}} = \frac{3!(A_{1})^{3}}{(4)3!} H_{3}(jw_{1}, jw_{1}, jw_{1})|$$
(2-92)

The other combinations can be carried out similarly. For the above cases we make the following observations: both eqns. (2-89) and (2-90) are similar to obtaining the output at $\omega_a + \omega_b + \omega_c$, and therefore we see a 3! (=6) multiplication factor*, which accounts for the six combinations at $\omega_a + \omega_b + \omega_c$ that were mentioned earlier; eqn. (2-91) is similar to obtaining the output at $2\omega_a + \omega_b$, and therefore has a multiplication factor of (3!/2!) = 3, which again is in accordance with our earlier discussion; eqn. (2-92) is like evaluating the output at $3\omega_a$, and hence has a multiplication factor of (3!/3!) = 1.

In section (2-5), we dealt with the analysis of multiple input nonlinear circuits. In obtaining the sinusoidal steady-state response of such

^{*}The constant factor 4 in the denominator appears consistently in all the output terms, and is therefore not regarded as a variable multiplication factor here. This factor appears due to the way x(t) was expressed in eqn. (2-81).

circuits the material of this section is still applicable. However, care must be taken in keeping track of the various input frequencies, and their associated transfer functions, when such an analysis is warranted.

CHAPTER 3

COMPUTER-AIDED ANALYSIS USING VOLTERRA SERIES

3-1. Introduction

The adapting of Volterra series method in a general simulation program has been regarded as difficult by various authors [30]. As such, virtually no effort has been spent on investigating the computational aspect of this method. Most previous works, such as [7], have endeavored to check the validity of this approach by applying it to specific circuit problems using a computer.

The only major effort in using the Volterra series for general nonlinear circuit analysis has been the development of the program NCAP [10,24]. A cursory review of this program reveals the inherent inefficiency in the computational approach with regards to storage and types of algorithms used. This inefficiency notwithstanding, there are severe limitation regarding the usefulness of the program: first, the program merely computes the numerical values of the nonlinear transfer function at the various program-prescribed combinations of the input frequencies, and does not compute all the transfer function values which are required to compute the complete output spectrum. Thus, NCAP does not yield the entire output spectrum information. Second, to compute up to an n-th order transfer function, the user must specify n input frequencies, which are assumed to be a sum of expomentials and not real sinusoids. The program, therefore, is severely limited in its usefulness from the point of view of a user who may only be interested in obtaining the output spectrum - say, for example, up to the third order response to two sinusuidal inputs - and has little use for the

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numerical values of the transfer functions at the program prescribed frequencies.

In this section we look at the computational aspect of the Volterra series method for general simulation purposes and then present the basic algorithms for adapting this method for the spectrum and distortion analysis of nonlinear circuits with polynomial type nonlinearities.

In section 3-2, we present a brief overview of symbolic analysis in linear circuits, and then describe the reason why a symbolic approach is particularly useful in adapting Volterra series for general simulation. Section 3-3 deals with the implementation of the symbolic approach, and also contrasts the computational effort between a numerical approach and the particular symbolic approach used here. The algorithm for obtaining the complete output spectrum and the various distortion indices is described in section 3-4. A description of the computer implementation of these algorithms is given in section 3-5.

3-2. Why a Symbolic Analysis Approach.

The symbolic analysis of circuits involves the computation of the a_i and b_i for network functions in the form

$$F(s) = \frac{N(s)}{D(s)} = \frac{\sum_{i=1}^{n} s^{i}}{\sum_{i=1}^{n} b_{i} s^{i}}$$
(3-1)

when all circuit elements are known. The more general form

$$F(s;x_{1},x_{2},...,x_{n}) = \frac{N(s;x_{1},...,x_{n})}{D(s;x_{1},...,x_{n})}$$
(3-2)

applies when some elements of the circuit x_i are kept as symbols. The advantages of symbolic analysis have been recognized previously [25,27]. One

particular advantage, and the one which is relevant to our problem here, is that the numerical evaluation of a function at discrete points is much easier and faster once the symbolic function is obtained than working repeatedly with a circuit analysis program. With this brief overview of symbolic analysis, we now proceed to answer the question: Why use a symbolic ana ysis approach for adapting the Volterra series method for general circuit analysis?

As pointed out in the previous sections, a nonlinear circuit is completely characterized by its Volterra kernels, or their transforms – the generalized transfer functions. These transfer functions are then directly related to the various order sinusoidal steady-state responses, as described in Chapter 2. The n-th order transfer function is determined from the following equation (see Chapter 2):

$$\underline{H}_{n}(s_{1},\ldots,s_{n}) = [\underbrace{Y}_{i=1}(\sum_{j=1}^{n} s_{j})]^{-1} \underline{I}_{n}(s_{1},\ldots,s_{n})$$
(3-3)

where $Y(\sum_{i=1}^{n} s_i)$ is the reduced node admittance matrix evaluated as $s_1 + s_2 + \cdots + s_n$, and \underline{I}_n is the n-th order current source vector due to the nonlinear elements. To compute the output spectrum, we evaluate H_n at the various and many frequency combinations. From eqn. (3-3) it should be clear that such an evaluation will entail the inversion of the reduced node admittance matrix at each of these frequency combinations. Using combinatorial analysis, it has been shown [22] that for an input consisting of M sine waves, the number of inversions involved in an n-th order response, given by $N_{n,m'}$ is:

$$N_{n,m} = \begin{pmatrix} 2M+n-1\\n \end{pmatrix}$$
(3-4)

Thus, for a 3-tone input and up to a third order analysis, the number of inversions is approximately 285. For higher order responses, this number grows very rapidly.

Two basic approaches available for handling this inversion process are: 1. Numerical approach, or 2. Symbolic approach. The advantage of evaluating symbolic transfer functions mentioned earlier makes the symbolic approach more attractive. How much advantage is gained in using a symbolic analysis depends on how much computational effort is expended in obtaining the symbolic inverse of the reduced node admittance matrix. Thus, an efficient scheme for obtaining the symbolic inverse must be used to efficiently adapt the Volterra series method for computer aided analysis. The determination of the symbolic inverse will be the subject of section 3-3.

The reasons presented above stem from looking at the computational aspect of adapting Volterra series for computer-aided analysis. There are other advantages gained from using a symbolic analysis. An important one is that the generalized transfer functions can be obtained as functions of s_i once the inverse of the reduced node admittance matrix is obtained as a symbolic function of s. This can be seen from examining eqn. (3-3). The formation of the n-th order current source vector is a bootstrapping operation, as was pointed out in Chapter 2. That is, an n-th order source is formed from transfer functions of order less than n. The first-order transfer function vector is determined from a column^{*} of the symbolic inverse of the reduced node admittance matrix. The second order current sources, which

*This is assuming a single input circuit.

depend on the elements of the first order transfer function vector, are therefore formed from this column of $[Y(s)]^{-1}$. The second-order transfer function vector is obtained by pre-multiplying the second-order current source vector by $[Y(s_1+s_2)]^{-1}$, according to which the second-order transfer function vector eventually depends on the entries of inverse of the node admittance matrix evaluated at (s_1+s_2) . The third- and higher-order transfer functions have a similar dependence. Thus, an inverse of the reduced node admittance matrix in symbolic form, with s retained as a symbol, also yields a functional description of the nonlinear transfer functions. A concomitant advantage of this functional description is that theorems from multidimensional theory [5] (such as initial value, final value, etc.) can then be used to gain more insight into the workings of the circuit.

E231 has developed recursive relationships to estimate the error incurred in the truncation of the series solution. This error was directly related to the l_1 norm of the linear kernel function, which, in turn, is related to the poles and residues of the linearized system. Thus, we can get an estimate of the accuracy of our solution through the pole-residue information provided to us by the symbolic analysis.

3-3. Symbolic Analysis Method

Symbolic circuit analysis by digital computer has been of considerable interest in the past decade. Many algorithms and methods have been derived to obtain symbolic transfer functions of linear circuits [20]. Most of these methods use tree enumeration [26], signal-flow graphs [20], or purely numerical methods [27] to obtain symbolic transfer function between the input and the output. These approaches are basically useful for single-input, single-output systems. The inversion of the reduced node admittance matrix to obtain the open-circuit impedance matrix, which is the problem we are

dealing with, is basically a multi-input, multi-output problem. The methods mentioned above can be adapted for solving the problem at hand; however, the generation of multiple symbolic functions using these approaches many not be satisfactory because of excessive computer time requirements. Some other approach is definitely warranted.

Published methods [16-18] for inverting the nodal admittance matrix when the elements are rational functions of the Laplace transform variable s use pivotal techniques. It may appear that, since it is easy to program a computer to perform polynomial arithmetic, these pivotal-techniques are a natural way to approach the symbolic inversion problem. Results from the use of such a technique have proved to be disappointing, mainly due to the following reasons:

(a) The process of inversion transforms the nodal admittance matrix, which contains terms of the form as $+\frac{b}{s} + c$, into a matrix in which every element is a rational function of s. The pivotal technique produces the inverse matrix where common factors appear between numerator and denominator, and unless some mechanism is built into the process whereby these common factors are recognized and removed, the elements produced will have polynomials of excessively high order.

(b) When the circuit complexity is high, the evaluation of the symbolic function at high frequency values can give rise to numerical problems. For example, a circuit with 8 poles will have an s^8 term in the characteristic polynomial. When evaluated at 10 Mrad/sec, this term produces a number equal to 10^{56} . Of course, this problem can be alleviated by obtaining a partial fraction expansion (PFE) form for the transfer functions. But this again entails additional computations – not to mention the numerical instability problems involved in root finding.

(c) It has also been found that pivotal techniques become numerically unstable for higher order circuits. -

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We therefore seek another alternative for obtaining the symbolic form of the open circuit impedance matrix.

An approach based on the state variable formulation can be used to achieve this goal. Specifically, consider the general p-port augmented linear circuit of Fig. 3-1(a). We wish to solve for the transfer impedances, $z_{ij}(s)$, i,j = 1,2,...,p, from the j-th port to the i-th port. Knowing these transfer impedances, we can write for the p-port:

$$\underline{V}(s) = \underline{Z}(s)\underline{I}(s) = [\underline{Y}(s)]^{-1} \underline{I}(s)$$
 (3-5)

where

$$\underline{V}(s) = [V_1(s) \ V_2(s) \ \dots \ V_n(s)]$$
 (3-6)

$$Z(s) = [z_{ij}(s)]$$
 (3-7)

and

$$\underline{I}(s) = [I_1(s) \ I_2(s) \ \dots \ I_n(s)]$$
(3-8)

Note that the vector $\underline{V}(s)$ contains entries which are the output voltages and voltages that control the nonlinear element characteristics in the nonlinear circuit.

To obtain Z(s) symbolically, we write for the network of Fig. 3-1(b), the following state equations:

 $\frac{x}{x} = A_{x} + B_{1}$ (3-9)

$$\underline{v} = C_{\mathbf{X}} + D_{\mathbf{i}} \tag{3-10}$$

where <u>x</u> is the vector of state variables, and \underline{v} and \underline{i} are vectors whose 48



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Figure 3-1. Determination of $[Y(s)]^{-1} = Z(s)$ for the p-port network using state equations.

transforms appear in eqns. (3-6) and (3-8), respectively. Taking the Laplace transform of eqn. (3-9) and (3-10), and solving for V(s), we get:

$$\underline{V}(s) = [\underline{C}(s\underline{J}-\underline{A})^{-1} \underline{B} + \underline{D}] \underline{I}(s)$$
 (3-11)

and, therefore, we get Z(s) to be

$$Z(s) \equiv \left[C(sI-A)^{-1} B + D \right]$$
(3-12)

which is identically the inverse of the reduced node admittance matrix.

The matrix (sI-A) can be inverted by applying the similarity transformation as follows:

$$A = M \Lambda M^{-1}$$
 or $\Lambda = M^{-1} A M$

$$\underline{M}^{-1}(\underline{s}\underline{I}-\underline{A})\underline{M} = \underline{s}\underline{I} - \underline{M}^{-1}\underline{A}\underline{M} = \underline{s}\underline{I} - \underline{M} = \underline{M}^{-1}\underline{A}\underline{M} = \underline{M}^{-1}\underline{M} = \underline{M}^{-$$

...

or

$$(s_{1}-A)^{-1} = M(s_{1}-A)^{-1} M^{-1}$$
 (3-13)

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where the inverse of $(sI - \Lambda)$ is simply diag $\{(s-\lambda_1)^{-1}, (s-\lambda_2)^{-1}, \ldots\}$ where λ_i are the eigenvalues^{*} of the A matrix and M is the modal matrix. Substituting eqn. (3-13) into eqn. (3-12), we get,

$$Z(s) = [C_{M}(sI - \Lambda)^{-1} M^{-1} B + D]$$

= $[C_{M}(sI - \Lambda)^{-1} B + D]$ (3-14)

where $\hat{c} \triangleq c_{M}$ and $\hat{B} \triangleq M^{-1}B$. Equation (3-14) yields the entries of Z(s) in partial fraction expansion form, which, as mentioned previously, is a more desirable form from a computational standpoint. All information about Z(s)

^{*}Here we assume distinct eigenvalues; the repeated eigenvalues can be handled similarly.

is contained in the matrices \hat{e} , $\hat{\theta}$, \hat{p} and a vector containing the eigenvalues. An algorithm for implementing this approach is given in Fig. 3-2. It should be noted that the approach used here is completely numerical and does not involve any coding and decoding of symbols.

Now that an algorithm for obtaining the symbolic Z(s) is defined, we can make a comparison of the computational effort involved between using a symbolic inverse and the numerical inverse of the node admittance matrix at each frequency point.

The computational trade-off between the symbolic approach and a numerical approach for matrix inversion is very problem dependent. While a clear-cut winner cannot be established, a tentative answer can be obtained by noting the operations count, defined in terms of multiplications and additions, involved in the two schemes.

In the case of the numerical approach, the number of independent nodes, n, and the number of branches, b, are the most important quantities for determining the computational effort along with the number of frequency points at which the output is desired. Assuming that no sparse matrix techniques are used, the numerical inversion of an (nxn) matrix requires $O(n^3/3)$ units of work, where $O() \equiv$ "order of", and 1 unit of work = one addition and one multiplication. For k frequency points, the work becomes $O(kn^3/3)$. This does not involve book-keeping and other pre- and post-processing steps such as pivoting and iterative refinement, which are usually necessary to insure reliability and robustness of the algorithm.

In the case of symbolic inversion using our approach, the important parameters in the computational effort are the dynamic degrees of freedom, d, and the number of ports, p, where voltages and currents are injected or measured. Using the QR algorithm [20,28] for computing the eigenvalues of



Fig. 3-2. Algorithm for inverting Y(s) symbolically.

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the A matrix, the operation count is $0.8d^3$). The total work required for obtaining the inverse at k frequency points is therefore $0(8d^3 + kdp^2)$. The number, p, depends on the number of nonlinearities in the circuit, and is usually small. Also, if the network complexity is less than the number of nodes, the symbolic approach would, in general, require less computational effort. As far as accuracy is concerned, both the QR algorithm and the Crout's algorithm with pivoting and iterative refinement yield accurate results.

The efficiency of the symbolic method rests heavily upon the availability on an efficient process for forming the state equations. The hybrid analysis method [19,20], which essentially reduces to the analysis of a resistive network, is well-suited for our purposes here.

3-4. Spectrum and Distortion Analysis Algorithm

The output spectrum and distortion indices for a nonlinear circuit with polynomial type nonlinearities can be computed on the basis of the material of Chapters 3 and 4. A flow-chart of the basic algorithm for such a computation is given in Fig. 3-3. We describe the steps involved in the follow-ing paragraphs:

<u>Step 1</u>: For the given nonlinear circuit, determine the dc operating point. Expand each nonlinear function into a Taylor series about the operating point to get a polynomial representation for the nonlinear element in terms of the incremental quantities. Thus, for example, a forward-biased diode having the "global" V-I representation

$$I = I_{e}[exp(qV/nkT) - 1]$$
 (3-15)

can be expanded into a Taylor series to yield the following incremental v-i representation:



Figure 3-3. Algorithm for Spectrum and Distortion Analysis.

$$i = I_0 \frac{q}{mkT} v + \frac{I_0}{2!} (\frac{q}{nkT})^2 v^2 + \frac{I_0}{3!} (\frac{q}{nkT})^3 v^3 + \dots$$
(3-16)

where $\mathbf{I}_{\mathbf{0}}$ is the dc operating current.

<u>Step 2</u>: Lump the linear part of the nonlinear elements with the existing linear network to form the augmented linear network. Extract as ports the nonlinear element branches and the branches that control the nonlinear element characteristics (dependent nonlinear element case), along with the output and source branches, from the augmented linear network. Let $\underline{V} = [V_1 \ V_2 \ \cdots \ V_p]$ and $\underline{I} = [I_1 \ I_2 \ \cdots \ I_p]$ denote the vector of voltages and currents for these ports, respectively.

<u>Step 3</u>: Using a symbolic analysis algorithm (see Fig. 3.2), obtain the entries of the Z matrix as a function of s, where

$$V(s) = Z(s) I(s)$$
 (3-17)

For each of the input sources, and their associated frequency tones, compute the first-order output voltages at each of the extracted ports by using the appropriate entries of the Z matrix. This step amounts to letting $s = j\omega_{i}$ in $z_{ij}(s)$, the entries of <u>Z</u>(s).

<u>Step 4</u>: The second-order output spectrum is evaluated using the following relationship:

$$V_{2}(s_{1},s_{2}) = Z(s_{1}+s_{2}) \underline{I}_{2}(s_{1},s_{2})$$
(3-18)

The vector $\underline{I}_2(s_1,s_2)$ is the second-order current source vector, which is formed by using the coefficients associated with the quadratic term of the nonlinear element and the first-order output at the controlling port(s) of the nonlinearity. The latter information was obtained in step 3. The given input tones are taken two at a time in eqn. (3-18), along with the informa-

tion derived in Chapter 2, to evaluate the output voltages at each of the p-ports.

The third-order output spectrum is obtained in exactly the same manner. The first- and second-order outputs are used to form the third-order current source at each combination frequency, which is then pre-multiplied by evaluating Z(s) at the combination frequency.

<u>Step 5</u>: Perform a histogram analysis of all frequency points and combine the responses at points which are repeated. The distortion indices are computed using:

$$HD_{2} = \frac{|V_{0}(2\omega_{i})|}{|V_{0}(\omega_{i})|}$$
(3-19)

$$HD_{3} = \frac{|V_{0}(3\omega_{i})|}{|V_{0}(\omega_{i})|}$$
(3-20)

where HD_2 and HD_3 denote the second and third order harmonic distortion in-

3-5. Program PRANC.

The <u>Program</u> for <u>Analysing Monlinear Circuits</u>, known as PRANC, is a digital computer program, written in FORTRAN IV, that computes up to the third-order complete output spectrum of a nonlinear circuit with polynomial nonlinearities driven by up to two multi-frequency inputs.^{*} In the process it computes the Volterra transfer functions at each of the frequency combinations involved.

As mentioned previously, the solution of the nonlinear circuit problem reduces to the repeated solution of the linear circuit. To efficiently han-

*Thus, mixer-type circuits can be analyzed using PRANC.

dle this basic problem, PRANC uses a semi-symbolic approach [20] for analysing the augmented linear circuit. Specifically, the inverse of the reduced node admittance matrix is obtained in terms of the symbol s using the state equation formulation as described above.

The state equations for the linear circuit are formulated via the Hybrid analysis method [19,20]. If T denotes port branches in the tree [20] and C denotes port branches in the co-tree of a linear circuit, then the Hybrid analysis yields the following relationship:

$$\begin{bmatrix} H_{11} & H_{12} & H_{13} & H_{14} \\ H_{21} & H_{22} & H_{23} & H_{24} \\ H_{31} & H_{32} & H_{33} & H_{34} \\ H_{41} & H_{42} & H_{43} & H_{44} \end{bmatrix} \begin{bmatrix} i \\ v_{c} \\ v_{T} \\ i_{c} \end{bmatrix} = \underline{0}$$
(3-21)

By suitably forcing the various ports in the linear circuit into the tree and co-tree branches, PRANC uses the (3-21) formulation for setting up the state equations. All capacitor branches are extracted as ports which necessarily become part of the tree and all inductors, nonlinear element branches (which are assumed to be voltage controlled), and input and output branches, are extracted as ports which are forced as part of the co-tree. The matrix H is obtained in a form where $H_{11} = I$ (I being the identity matrix), $H_{12} = H_{21} = 0$, $H_{22} = I$. This yields the capacitor currents and the inductor and nonlinear element branch voltages in terms of known variables. Thus, the A, B, C, and D matrices in the state and output equations (see eqns. 3-9 through 3-12) are obtained from the submatrices of H. The formulation of eqn. (3-21) is quite fast, since it only involves the analysis of a resistive network.

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It is noted that the matrix H may not exist in idealized circuits. However, for most practical circuit this matrix is almost certain to exist [20]. It should also be noted that the above formulation of state equations tacitly assumes that no degenerate cutsets (all inductor-current source cutset) or degenerate loops (all capacitor-voltage source loop) are present in the linearized circuit. These restrictions are not very severe, especially when the realistic lossy models of circuit components are taken into account.

The next step in the PRANC algorithm is to determine the eigenvalues and the eigenvectors of the A matrix. For this purpose, the double QR algorithm [28] for obtaining the eigenvalues is employed. The basic steps, such as matrix balancing, reduction to Hessenberg form, shift of origin, are included in this algorithm to make it efficient and reliable. The eigenvectors are also obtained in the process.

All information about the inverse of the reduced node admittance matrix is stored as three matrices and a vector. The matrices are \hat{B} , \hat{C} , and D (see eqns. 3-14), and the vector contains the eigenvalues. It is noted that the solution of eigenvectors for repeated eigenvalues can be a numerical unstable process [29]. Thus, the programs outputs a diagnostic message when such a case occurs.

The first-order voltage response at the prescribed ports is now computed from the entries of the open-circuit impedance matrix. These ports include: source port, output ports, nonlinear element ports, and ports which control the nonlinear element characteristics. The response is calculated for each user prescribed frequency, and stored as a two-dimensional array: port number vs. the frequency number.

The second-order voltage response is computed at each distinct combination of the input tones taken two at a time. The ports of interest are the same as that for the first-order response. The second-order current source vector, at a particular frequency combination, is formed by considering the nonlinear element type and the voltage(s) controlling it, which is determined from the first order response array. This vector is pre-multiplied by the open-circuit impedance matrix evaluated at the combination frequency to obtain the second-order transfer function vector at that frequency. The response voltage at this frequency is then determined from the transfer function value. The second-order transfer function values are again stored as a two-dimensional array: port number and the particular frequency combination.

The third-order response is determined similarly. The third-order current source vector is formed by properly picking out the values of the first- and second-order transfer functions. The indexing of the arrays is of critical importance to the efficient implementation of this scheme.

Since the hybrid analysis forms the basis for forming the open circuit impedance matrix, the following linear elements are allowed by the program^{*}: resistors, capacitors, inductors, voltage or current sources, and all four types of controlled sources. The nonlinear elements are assumed to be voltage controlled, with the following polynomial descriptions:

$$i_p = a_1 f [v_p] + a_2 f [v_p^2] + a_3 f [v_p^3]$$
 (3-22)

^{*}A direct nodal analysis would only allow for voltage controlled current source.

$$i_p = a_{10}v_q + a_{01}v_r + a_{20}v_q^2 + a_{02}v_r^2 +$$

$$a_{11}v_{q}v_{r} + a_{30}v_{q}^{3} + a_{03}v_{r}^{3} + a_{12}v_{q}v_{r}^{2} + a_{21}v_{q}^{2}v_{r}$$
 (3-23)

where i_n and v_n are currents and voltages across branch n, f is a linear operator of the type $\frac{d}{dt}$, $\int_{-\infty}^{t}$, or constant, and a_{ij} are constants. It should be noted that eqn. (3-23) models a 3-port device.

In the present version, PRANC imposes the following restrictions on the circuit parameters: maximum number of elements (both linear and nonlinear) = 60; maximum number of nonlinear elements = 10; maximum number of dependent nonlinear elements (eqn. 3-23) = 5; maximum number of reactive elements = 20; maximum number of independent nodes = 30; number of input frequencies = 5. These restrictions can be relaxed if desired. The modular structure and algorithms of PRANC makes it possible to extend the order of analysis in a straightforward manner. The limit on the highest order will eventually be dictated by the storage restrictions of the computer.

The validity of the results obtained from using PRANC has been verified through hand-worked examples and with the results obtained from using NCAP [24]. In Chapter 4 we present examples showing the results obtained from the use of PRANC.

CHAPTER 4

USER'S GUIDE FOR PRANC

4-1. Introduction

Based upon the theory of Chapter 2 and the algorithms of Chapter 3, PRANC (<u>Program</u> for <u>Analyzing Nonlinear C</u>ircuits), a digital computer program, has been developed for the sinusoidal steady state analysis of circuits with multiple nonlinear elements and multiple multi-frequency input sources. The complete listing of the program is contained in Chapter 5.

The usefulness of PRANC is not restricted only to users who are wellversed in the Volterra series method; users with a basic knowledge of the significance of sinusoidal steady state analysis, eigenvalues (poles) of a linear system, and other related circuit analysis concepts can easily use the program, and understand the information provided by it. By suitably translating the circuit analysis problem into a prescribed sequence of well-defined statements - to be presented in this chapter - any user can use PRANC as an analysis tool.

To methodically and effectively use PRANC, the user is recommended to follow a three-step process:

- 1. Preliminary Data Preparation
- 2. Translation of Data for Analysis
- 3. Interpretation of Analysis' results.

The contents of this Chapter are organized on the basis of these steps.

In section 4-2, the considerations entailed in the preliminary data preparation are presented. The allowed elements, the user available options, and the program restrictions in terms of the circuit size and features are discussed.

Section 4-3 presents the sequence of input cards (input data to the program) for PRANC. The formats for each card in the sequence is described. The interpretation of the program output is the subject of section 4-4. Finally, several examples are presented in section 4-5 to illustrate the use of PRANC.

4-2. Preliminary Data Preparation

4-2.1 <u>Allowable Element Types</u>: The first step in any circuit analysis problem is the drawing of its complete circuit model. This diagram should include all elements which can be identified by **PRANC**.

The present version of PRANC is capable of identifying the following element types, which are depicted in Fig. 4-1:

- Independent voltage source
- Linear Components: Resistor, Inductor, and Capacitor
- Linear Dependent Sources: Voltage-controlled Voltage source, Current-Controlled Current-Source, Voltage-controlled current-source, and Current-controlled voltage-source.
- Nonlinear Components: Resistor, Inductor, and Capacitor
- Nonlinear Dependent Source: Voltage-controlled current-source.
- Bipolar Junction Transistor

The polarity convention assumed by PRANC is shown in Fig. 4-1. The current voltage relationships for linear elements are well-known. The nonlinear elements are assumed to be represented in the form of polynomials of branch voltage(s). Thus, PRANC handles nonlinear elements expressed as:






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Figure 4-1 (Contd.) PRANC Element Definitions

$$i_{NL} = a_1 f[v] + a_2 f[v^2] + a_3 f[v^3]$$
 (4-1)

or

$$NL = a_{10}v + a_{01}u + a_{20}v^2 + a_{02}u^2 + a_{11}vu$$

$$+ a_{30}v^{3} + a_{03}u^{3} + a_{21}v^{2}u + a_{12}vu^{2}$$
(4-2)

where f is an operator of the form $\int_{r} \frac{d}{dt}$, or a constant, u and v are branch voltages, and i_{NL} is the current across the nonlinear element. It should be noted that eqn. (4-1) is adequate to model a nonlinear capacitor, a non-linear inductor, or a nonlinear resistor, and that eqn. (4-2) is suitable to model a 3-port or a 2-port voltage controlled nonlinear dependent source.

The representation of a nonlinear device in terms of a polynomial is covered in several papers and reports [7,10]. An example of the development of a polynomial representation for a semiconductor diode is given in Appendix A.

It should be noted that if a current-controlled nonlinear element is present in the circuit, the reversion of the series may be used. That is, given

$$v_{NL} = a_1 i_{NL} + a_2 i_{NL}^2 + a_3 i_{NL}^3 (a_1 \neq 0)$$
 (4-3)

We can express

$$i_{NL} = A_1 v_{NL} + A_2 v_{NL}^2 + A_3 v_{NL}^3$$
(4-4)

where

$$A_1 = \frac{1}{a_1}$$
 (4-5)

$$A_2 = -\frac{a_2}{a_1^3}$$
(4-6)

$$A_{3} = \frac{1}{a_{1}^{5}} (2a_{2}^{2} - a_{1}a_{3})$$
(4-7)

where i_{NL} and v_{NL} are the current and voltage across the nonlinear element, respectively.

The element node numbers are shown by symbols xx and yy in Fig. 4-1. For devices representable in terms of a pair of nodes, or a collection thereof, the node numbers are assigned by the user. The node numbering for a bipolar junction transistor is done internally within the program once the node number for the base terminal of the transistor has been specified by the user. The model for the transistor used in **PRANC** is based on Narayanan's work [7], and is shown in Fig. 4-2 along with the programassigned node numbers.

4-2.2. User Available Options:

PRANC performs the complete sinusoidal steady state analysis of a nonlinear circuit. In accomplishing this task, the program obtains the state equations and the eigenvalues for the linearized circuit, forms the entries of the open circuit impedance matrix* in partial fraction expansion form, and then computes the first-, second-, and third-order transfer function values at each combination of the positive and negative input frequency values. The output voltage at each frequency component is then computed *This is an equivalent form of the inverse of the reduced node admittance.

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from the transfer function. The sinusoidal steady state response is obtained after combining the various order responses at repeated frequency values.

In order to provide flexibility to the user to control the program output, several options have been incorporated in PRANC. These are described next.

1. <u>Frequency Sweep</u>. Many applications in distortion and spectrum analysis of nonlinear circuits calls for the study of the effect of frequency on the distortion products. A frequency sweep capability, which allows the user to request multiple analyses of a given circuit over a range of generator frequency values in a single execution, is provided by PRANC. This option can be called for by specifying the acronym FS on the option card.

PRANC allows the user to sweep up to five tones*. This allows the user to study the effect of frequency on the second- and third-order intermodulation products independently. In a third order analysis, a combination of three input frequencies is taken at a time to compute the amplitude of an intermodulation product; sweeping up to three frequencies is therefore sufficient to study the effect of frequency on an intermodulation product. Thus, given a fixed intermodulation frequence $\omega_{IM} = \omega_1 + \omega_2 - \omega_3$, where ω_1, ω_2 , and ω_3 are the input frequencies, the effect of a change in the input frequencies on ω_{IM} can be investigated by simultaneously incrementing ω_1, ω_2 , and ω_3 by a fixed amount across the band of interest. The study of the effect of frequency on a second-order distortion product is done similarly by varying two tones at a time. Both linear and logarithmic frequency sweeps are available on PRANC.

*Since PRANC generates the negative of the input frequencies internally, this is equivalent to sweeping ten frequencies.

2. <u>Multiple Input Sources</u>. Ordinarily PRANC assumes the nonlinear circuit to have a single multi-frequency input source. However, when a two source circuit, such as a mixer circuit, is to be analyzed, the acronym MX (<u>mixer</u>) on the option card can be used. PRANC will, in such a case, look for the description of the second input source. The first generator can have up to four input tones, and the second generator (the "local oscillator") only <u>one</u> input frequency.

3. <u>Print and Plot Complete Spectrum</u>. After computing the transfer functions and output voltages, PRANC performs a histogram type analysis of all frequency points to compute the complete output spectrum across a requested circuit element for printing and plotting purposes. Often times the user may be only interested in the transfer function and output voltage values, and may have no use for the complete output spectrum. In order to provide the flexibility for suppressing the printing and plotting of the complete output spectrum, an option to be specified by the user is available. By using the acronym PC on the option card the user can request for a print-out and plot of the complete output spectrum; an absence of PC on the option card signals the program to suppress the histogram analysis feature.

4. <u>Output Port Print-out Selection</u>. PRANC performs the analysis of the nonlinear circuit on a port basis. Two types of ports are extracted in the analysis: 1) Input and output ports specified by the user, and 2) controlling ports for the nonlinear elements. Depending on the number of nonlinear elements and the number of controlling voltage variables, the number of the extracted ports can become quite large and thereby result in an inordinately large amount of printed output if the transfer function and output voltage at each frequency component and at each of the ports is printed. To reduce

the amount of printed output, an option for the printing of selected output ports can be requested. By using the acronym AP (<u>All extracted ports</u>) on the option card, the transfer functions and output voltages at each of the extracted ports is printed; an absence of AP on the option card signals the program to print the transfer functions and output voltages at only the user-prescribed output ports.

5. <u>State Space Description Print</u>. The open circuit impedance matrix for the linearized circuit is obtained via the state space description (see eqn. 3-5). The user can request a print-out of this description by specifying the acronym SE on the option card. When SE is omitted from the option card, the printing of the A, B, C and D matrices is suppressed.

6. <u>Eigenvalue</u>, <u>Modal Matrix Print</u>. The eigenvalues or the poles of the linearized circuit, and their associated eigenvectors, are computed by PRANC. The user may access this information by specifying NM (natural modes) on the option card. The eigenvalues and the modal matrix are not printed when the letters NM are omitted from the option card.

7. <u>Open Circuit Impedance Matrix Print</u>. The open circuit impedance matrix for the Linearized circuit is obtained in partial fraction expansion form by PRANC. Each entry of this matrix is obtained in terms of a set of poleresidue pairs and can be written as:

$$z_{ij}(s) = \sum_{k} \frac{r_k}{s^{-\lambda}_k} + \text{ constant}$$
 (4-8)

where r_k is the residue associated with the pole λ_k . Knowing all the entries of the open-circuit impedance matrix in the form (4-8), it is possible to obtain the higher order transfer functions in terms of s_i [23]. By using 70

the acronym PR (pole-residue) on the option card, all information required to obtain each entry of the open circuit impedance matrix in the form (4-8) can be accessed from PRANC.

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8. <u>Debug Print</u>. The hybrid analysis formulation is used by PRANC to set up the state space description of the linearized circuit. All important intermediate results leading to the determining of the hybrid matrix can be obtained by the user by requesting a debug run. This option is invoked by specifying the acronym DB on the option card.

4-2.3. Program Restrictions

The present version of PRANC imposes the following restrictions on the circuit size:

Maximum number	of	elements (both linear and nonlinear) =	60
Maximum number	of	nonlinear elements ⁺ =	10
Maximum number	of	dependent nonlinear elements =	5
Maximum number	of	reactive elements =	20
Maximum number	of	independent nodes =	30
Maximum number	of	input frequencies* =	5
Maximum number	of	extracted ports** =	25
Maximum number	of	inputs =	2

In addition to the above size restrictions, there are other restrictions imposed by the algorithms used: the presence of degenerate (all capacitor-voltage source) loops or degenerate (all inductor-current source)

A bipolar transistor accounts for three nonlinear elements. *These are the sine wave input frequencies. The negative frequencies are generated within the program. **Number of extracted ports $\leq NO$ + NINL + 3NDNL + 1; NO \equiv number of requested outputs NINL = number of independent nonlinear elements NDNL = number of dependent nonlinear elements.

cutsets [20] will lead to erroneous results. It should be noted that this restriction is not severe when the realistic lossy models for capacitors or inductors are used. A series resistance with a capacitor or a shunt resistance with an inductor to account for the element non-idealities will insure the absence of any of the aforementioned degenerate cases.

Another restriction encountered in PRANC is related to the determination of the eigenvectors. It is well known [29] that the computation of the eigenvectors for repeated eigenvalues can be an ill-conditioned problem. Thus, whenever a linearized circuit has repeated eigenvalues, PRANC outputs a diagnostic message*. Again it is remarked that this restriction is not very severe. One can easily concoct simple network examples with repeated eigenvalues; but in real-life circuits, the probability of encountering repeated eigenvalues is very low - particularly when one considers the method of storing numbers in the finite length word of any digital computer.

To summarize this sub-section, the following three-step procedure is recommended to the user as part of the preliminary data preparation: <u>Step 1</u>: Examine the circuit under consideration to insure that all elements are recognizable by PRANC. Furthermore, insure that there are no degenerate loops or degenerate cutsets [20]. If such conditions exist, the following remedy is recommended: place a negligibly small resistor in a degenerate loop; place a negligibly small conductance in parallel with one of the elements of the degenerate cutset.

<u>Step 2</u>: Assign consecutive numbers to all elements in the circuit (including a bipolar transistor) from 1 to NB and all nodes in the circuit from D to NN, where NB is the number of elements (both linear and nonlinear) and NN is

^{*}It should be noted that this is due only to the numerical problems and that the theory of chapters 2 and 3 is still valid.

the number of independent nodes. Node number O is assumed to be the ground node. Insure that the circuit size does not exceed the limits imposed by the present version of PRANC.

<u>Step 3</u>: Note the number of linear and nonlinear elements, and the number and unit of the input frequencies. Based on the list of available options, select the ones desirable for the circuit analysis problem at hand.

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4-3. Input Description for PRANC

In this sub-section, the details of the prescribed sequence of cards needed for using PRANC are presented. After the preliminary data preparation step is done, the procedure for translating the circuit description into input data is straightforward.

Assuming that PRANC is stored in the computer, the sequence of cards needed for the analysis of a nonlinear circuit with a single source is shown in Fig. 4-3; the case of the two-input source circuit is shown in Fig. 4-4. There are basically six types of cards present in the input data for PRANC. These are: 1) Title card; 2) Option Card; 3) Analysis Parameter card; 4) Linear Component description cards; 5) Nonlinear component description cards; and 6) Generator description cards. The details of the contents of each of these card types are described next.

1. <u>Title Card</u>: This card is read in with an 80A1 form and is reproduced as the first line of the output.

2. <u>Options Card</u>: This card tells the program which options, described in section 4-2.2, are desired by the user. Each option has a two-letter acronym associated with it. These acronyms are summarized in Table 4-1. Starting in column 1 the user must punch a contiguous string of the acronyms re-





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Figure 4-4. Sequence of Cards for Two-Input Circuits

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quired to request the specific options. The card must therefore be in the following format:

Column	Format	Description
1-2	A2	First desired option acronym
3-4	A2	Second desired option acronym
5-6	A2	Third desired option acronym
•	•	
•	•	

See section 4-5 for examples.

3. <u>Analysis Parameter Card</u>: The analysis parameter card contains information regarding the number of linear elements, the number of nonlinear elements (the transistor should be counted as 1 nonlinear element by the user), the number of sinusoidal frequencies (\leq 5) in the input signal*, the unit of the input frequencies, and the type of frequency sweep (if desired). This card must be in the following format:

Column	Format	Description
1 - 2	15	No. of linear elements
3-4	12	No. of nonlinear elements
5	I1	No. of input frequencies
6-8	A3	Unit for the input frequencies
		use RAD for rad/sec. Hz for Hertz
9-11	A3	Type of frequency sweep, if desired;
		LIN for linear and LOG for logarithmic

*This does not include the local oscillator frequency in the case of a mixer circuit.

	Option Acronym	Option Description
1.	AP	Print all extracted ports output information
2.	DB	Debug for Hybrid analysis: print all intermediate results
3.	FS	Frequency sweep capability
4.	MX	Two-input circuit for analysis
5.	NM	Print eigenvalue and modal matrix information
6.	PC	Print and plot complete output spectrum
7.	PR	Print pole-residue information for the open-circuit impedance matrix
8.	SE	Print state-space description of the linearized circuit

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Table 4-1. Summary of Available User Options on PRANC

It should be noted that the I-format and the A-format are always right justified.

4. <u>Linear Component Description Cards</u>: Each branch containing a linear element save the independent source(s) and its impedance(s) must be described in terms of its topological connections, its element value and type, and its controlling branch number, if any. Each linear element description card must use the following format:

Column	Format	Description
1-3	13	Branch number
4-6	13	Positive (""rom") node number
7-9	13 .	Negative ("To") node number (Sign convention for PRANC is shown in Fig. 4-1)
10-11	Α2	Element type. The following element types and their acronyms are recognized by PRANC: R Resistance G Conductance L Inductance C Capacitance CV Current-controlled Voltage source VV Voltage-controlled Voltage source VC Voltage-controlled Current source CC Current-controlled Current source CC Current-controlled Current source CC Current-controlled Current in column 11: right-justified)
12-21	E10.3*	Element value of R,G,L,C, or dependent source.
22-24	13	Branch number for the controlling branch of CC, CV, VV, or VC. For other element

^{*(}Note: For an E-format input: the exponent appears as a signed two digit integer in the three right most columns of the format field, and is preceeded by a letter E, which is preceeded by the floating point value. Thus, for example, a 6.6μ F capacitor value should appear as:

 $\frac{12}{1} \frac{13}{6} \frac{14}{6} \frac{15}{6} \frac{16}{0} \frac{17}{0} \frac{18}{E} \frac{19}{-0} \frac{20}{6} \frac{21}{6},$

types this should be left blank.

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25 I1 This column is used to provide multiple output capability. A 1 in this column indicates that the current branch number is an output branch; a blank indicates otherwise.

5. <u>Nonlinear Component Description Cards</u>: Two cards are used to describe each nonlinear capacitor, inductor, resistor, or a dependent source. The first card describes the nonlinear component type and its connection in the circuit; and the following card, the second card, defines the coefficient values in the polynomial expansion of the nonlinear element (as per eqns. 4-1 and 4-2). The nonlinear components are assumed to have a voltagecontrolled current.

The format for the two cards required to define a two terminal nonlinear component is as follows:

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Column	Format	Description
1-3	13	Component number
4-6	13	Positive ("from") node number of the component
7-9	13	Negative ("to") node number of the component
10-11	A2	Element Type. The following acronyms are allowed for the various element types: NC Nonlinear Capacitor NL Nonlinear Inductor NR Nonlinear Resistor ND Dependent Nonlinearity (eqn. 4-2)
12-14	13	First controlling voltage branch 79

number for the dependent nonlinearity. These columns are left blank in the case of NC, NL, or NR.

15-17 I3 Second controlling voltage branch number for the dependent nonlinearity. These columns are left blank in the case of NC, NL, NR, or single-voltage-controlled dependent nonlinearity.

<u>Second Card</u>: This card is used to define the coefficients of the polynomial describing the nonlinear element described on the first card. The format for this card is:

Column	<u>1</u>	Format		Descript	ion
1-10		E10.3	or	Coefficient coefficient	a ₁ in eqn. (4-1) a ₁₀ in eqn. (4-2)
11-20		E10.3	or	Coefficient coefficient	a ₂ in eqn. (4-1) a ₀₁ in eqn. (4-2)
21-30		E10.3	or	Coefficient coefficient	a ₃ in eqn. (4-1) a ₂₀ in eqn. (4-2)
31-40		E10.3		Coefficient	a ₀₂ in eqn. (4-2)
41-50		E10.3		Coefficient	a ₁₁ in eqn. (4-2)
51-60		E10.3		Coefficient	^a 30 in eqn. (4-2)
61-70		E10.3		Coefficient	a ₀₃ in eqn. (4-2)
71-80		E10.3		Coefficient	^a 21 ^{in eqn. (4-2)}
1-10	(new card)	E10.3		Coefficient	^a 12 ^{in eqn. (4-2)}

Three cards are needed to describe each bipolar transistor in the circuit. The first card indicates that a transistor **is** present and also specifies the node number for the external base terminal. The second and third cards input the transistor parameters for the purpose of PRANC modelling. These parameters include the following (see Fig. 4-2):

Parameter No.Parameter NameDescription1nAvalanche Exponent80

2	V _{cB}	Collector-base bias Voltage
3	V _{cB0}	Avalanche Voltage
4	μ	Collector Capacitance Exponent
5	I c	Collector bias current
6	Icmax	Collector current at maximum d.c. current gain
7	а	h _{FE} nonlinearity coefficient
8	h FEmax	maximum d.c. current gain
9	k	collector capacitance scale factor
10	Ref	Diode non-ideality factor
11	° _{je}	Base-emitter junction space charge capacitance
12	c'2	Derivative of base-emitter diffusion capacitance
13	r _b	Base resistance
14	r _c	Collector resistance
15	c ₁	Base-emitter capacitance
16	c3	Base-collector and overlap capacitance

Once the external base terminal node, xx, has been specified by the user, the following node numbers are internally assigned by the program to the other terminals in the transistor model:

> xx + 1 : Internal Junction xx + 2 : External collector xx + 3 : External emitter

The user must therefore take caution in not assigning these node numbers elsewhere in the circuit.

For the bipolar junction transistor description, the following sequence of cards are used:

<u>First Card</u>: The format of the first card for the description of a BJT is identical to that for the two terminal nonlinear components. Accordingly, the following format is used:

Columns	Format	Description
1-3	13	Component number*
4-6	13	External base node number
7-9	13	(blank)
10-11	A2	The acronym TR in these columns signals the presence of a bipolar junction transistor.

A TR in columns 10-11 on the first card of the nonlinear description cards causes PRANC to read two additional cards describing the transistor parameters. The format and the order in which the parameters are read is as follows:

Second Card: Columns	Format	Description
1-10	E10.3	n : Avalanche Exponent Value
11-20	E10.3	V : Collector-base bias voltage value
21-30	E10.3	V _{cB0} : Avalanche voltage value
31-40	E10.3	µ : Collector capacitance exponent value
41-50	E10.3	I : Collector bias current value
5 1-6 0	E10.3	I cmax : Collector current at maximum d.c. gain value
61-70	E10.3	a : h _{FE} nonlinearity coefficient value
71-80	E10.3	^h FEmax: maximum current gain value

*Each transistor should be counted as one nonlinear component in the circuit.

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Columns	Format	•	Description
1-10	E10.3	k	: collector capacitance scale factor value
11-20	E10.3	Ref	: diode non-ideality factor value
21-30	E10.3	C _{je}	: Base-emitter junction space-charge capacitance value
31-40	E10.3	c'2	: Derivative of base-emitter diffusion capacitance value
41-50	E10.3	r _b	: base resistance value
51-60	E10.3	r _c	: collector resistance value
61-70	E10.3	с ₁	: base-emitter capacitance value
71-80	E10.3	c ₃	: base-collector and overlap

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In summary, the nonlinear component description cards are a sequence of cards where:

 Two cards are used to describe each nonlinear resistor, nonlinear capacitor, or nonlinear inductor;

2) Three cards are used to describe each nonlinear dependent source;

 Three cards are used to describe each bipolar junction transistor in the circuit.

6. <u>Generator Description Cards</u>: PRANC assumes the independent source to be a voltage source in series with an impedance, as shown previously in Fig. 4.1. The impedance can be a linear resistor, a linear capacitor, or a linear inductor. Two types of cards are required to describe the generator: the first card specifies the generator connection in the circuit and the succeeding cards describe the frequencies and their associated amplitudes along with the parameters for frequency sweep capability, if desired by the user. Only two nodes are needed to specify the connection of the generator to the circuit.

The input voltage source is assumed to have the following form:

$$v_{s}(t) = \sum_{i=1}^{n} A_{i} \cos(\omega_{i}t + \theta_{i}); n \leq 5$$
(4-9)

The user is therefore required to input the values for A_i , ω_i , and θ_i to describe the input source.

When the frequency sweep capability is requested by the user on the option card, the following three quantities must also be specified along with A_i , ω_i , and θ_i : 1) the number of steps or frequency increments; 2) the highest or terminal value of the frequency sweep; and 3) type of the desired sweep, which indicates whether the increment is to be linear (additive) or logarithmic (multiplicative).

It should be noted that the number of steps defines the number of times the circuit is to be analyzed. For linear sweeps the value of the increment is calculated by the program according to the expression:

$$INC_{i} = \frac{HFR_{i} - FR_{i}}{NSTP_{i} - 1}$$
(4-8)

where $INC_{i} \equiv frequency$ increment value for the i-th frequency,

HFR; = highest value for the i-th frequency,

 $FR_i = starting value for the i-th frequency,$

NSTP_i = number of increments for the i-th frequency, Similarly, for a logarithmic sweep, the increments are calculated as follows:

$$INC_{i} = \left[\frac{HFR_{i}}{FR_{i}}\right]^{NSTP_{i}-1}$$
(4-11)

(4-12)

In determining the value for the number of increments, the user should be aware that the highest and the starting frequency values each count as an increment. It should also be noted that multiple frequency sweep specifications always result in simultaneous increments of the frequency values involved. The largest defined "number of increments" value determines the number of analyses to be performed in such cases. As the analysis progresses, each frequency value will be incremented until its highest value has been reached, after which it will remain constant until all defined frequency sweeps have been satisfied.

The first card in the generator description card has the following input format:

Column	Format	Description
1-3	13	Positive ("from") node number for the generator
4-6	13	Negative ("To") node of the generator
7-8	A2	Source Impedance Type: _R, _L, or _C
9-18	E10.3	Source impedance element value

The cards following the above card provide information about each frequency value, along with its associated amplitude and phase, and its frequency sweep parameters. The format used to describe the i-th input frequency is as follows:

Column	Format	Description
1-10	E10.3	Amplitude value for the i-th frequency
11- 20	E10.3	i-th input frequency value (must be greater than 0)
21-30	E10.3	Phase value in degrees for the i-th frequency
31-40	E10.3	Highest value for the i-th input frequency. Should be left blank when frequency sweep capability is not desired.
41-42	12	Number of increments desired for the i-th frequency.

When two input sources are present in the circuit being analyzed, and the acronym MX has been included on the option card, the card immediately following the above "frequency description" cards is used to define the second source ("local oscillator") parameters. The second source is again assumed to be a voltage source with a series impedance of the resistive, inductive, or capacitive type. Only one frequency value is however allowed for the second source. The description of the second source must have the following format:

Column	Format	Description
1-3	13	Positive ("from") node number for the source
4-6	13	Negative ("To") node number for the source
7-8	A2	Source impedance type: R, L, or C
9~18	E10.3	Source impedance element value
19~28	E10.3	Amplitude value of source
29~38	E10.3	Source ("local oscillator") frequency value
39-48	E10.3	Phase value in degrees for the source 86

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In section 4-5 we shall present concrete examples to illustrate the typical sequence of cards used to translate nonlinear circuit problems for analysis using PRANC.

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4-4. Interpretation of PRANC Output

A typical PRANC output comprises a large volume of printed information. In general, even when all user available options are suppressed, the output consists of: 1) images of all input cards; 2) all circuit devices* with their associated parameters and polynomial representation of their nonlinearities; 3) the description of the augmented linear network; 4) the description of all extracted ports; and 5) the transfer functions and output voltages across the desired output ports. The transfer functions and the output voltages are printed for all non-negative ("positive" frequency spectrum) combinations of every positive and negative input sinusoidal frequencies**, in both cartesian and log polar form. Thus, if a two-tone generator is specified by the user, with $2f_2 > f_1 > f_2$, PRANC will print the transfer function and output voltage values at the following frequency combinations:

> First order : f₁,f₂ Second order : 2f1,f1+f2,f1-f2,0,2f2 Third order : 3f1,2f1+f2,f1,2f1-f2,f1+2f2,3f2,2f2-f1,f2

When the available user options are used, additional information about the circuit is provided by PRANC. The details of each of the available option was presented in section 4-2. We briefly repeat their functions here.

^{*}These include bipolar junction transistor parameters in the present version. **The user specifies orly the positive sinusoidal frequencies; PRANC generates their negative values within the program.

When the acronym SE is punched on the option card, PRANC will print the complete state space formulation for the augmented linear network. It is well-known [20] that, like the nodal or loop analysis, a linear network is completely characterized by its state space description. By isolating the dynamic (energy storage) elements in the linear network, the state equation description emphasizes the dynamic character of the linear part of the nonlinear circuit under study. PRANC isolates the capacitor voltages and the inductor currents as the state variables for the linearized network. It prints the A, B, C, and D matrices of the following vector equations:

$$\frac{x}{x} = Ax + Bi$$

$$\frac{y}{y} = Cx + Di$$
(4-13)

where the vector $\underline{x} = [v_{c1} \ v_{c2} \cdots v_{cn} : i_{L1} \ i_{L2} \cdots i_{Lk}]^T$, the vector $\underline{i} = [i_1 \ i_{2} \cdots i_{p}]^T$,

and the vector $\underline{y} = \begin{bmatrix} v_1 & v_2 \cdots & v_p \end{bmatrix}^T$.

Here v_{ci} is the i-the capacitor voltage, i_{Li} is the i-th inductor current, and v_k and i_k are the voltages and currents for the k-th extracted port, respectively. The order in which the states are arranged is identical to the order in which the capacitors and inductors appear in the augmented tinear description, which is always printed by PRANC in a typical successful execution of the program.

When the acronym NM appears on the option card, the eigenvalues (poles) and the modal matrix for the augmented linear network is printed. The significance of this information is well-known [20]: the poles have a direct bearing on the linear system response and stability; the modal matrix can be used to study the zero-input response along with the observability and controllability properties of the linearized system.



The presence of the acronym PR on the option card causes PRANC to print the pole-residue information of each entry of the open-circuit impedance matrix for the p-port augmented linear circuit. This information can be used to construct the higher order transfer functions in terms of the transform variables s_i . Multi-dimensional transform theory [5] can then be applied to these transfer functions to get more insight into the operation of the nonlinear circuit.

The presence of the acronym AP on the option card causes PRANC to print the transfer function and the output voltage values for all the ports extracted for analyzing the nonlinear circuit problem. These ports include: 1) input source port(s); 2) user requested output ports; 3) the ports at which the nonlinear elements are present; and 4) the ports which control the nonlinear element characteristics.

When the acronym PC is present on the options card, the complete steady-state response at the "most desirable", user-specified output port is obtained and printed. The logarithm of the output voltage is also plotted as a bar-graph, which has the same display characteristic as a spectrum analyzer. As mentioned previously, frequency components appearing in the first-order response may appear in higher-order responses also. The function of the option under consideration is to combine these responses and print the response at only the set of distinct frequencies.

The use of the debug option (DB) causes PRANC to print the intermediate results of hybrid analysis of the augmented linear circuit. This option has been incorporated for the debugging of the linear circuit analysis and is not recommended for use during a typical run. An understanding of hybrid analysis [20] is necessary to interpret the output -- which can be quite voluminous - from the debug run.

4-5. Examples using PRANC

A set of examples are presented in this section to illustrate the use of PRANC for obtaining the steady-state response of nonlinear circuits. Each example will contain the problem statement, the sequence of punched data cards, the computer printed output, and some remarks on the printed output.

Example 4-1: Single Stage Untuned Amplifier Circuit

Consider the untuned, bipolar transistor amplifier of Fig. 4-5. The input source comprises of three frequencies. The sequence of data cards used are shown in Fig. 4-6 and Fig. 4-7. Note that the second card in the sequence, referred to as the option card previously, calls for the polerresidue information (acronym PR) and the printing and plotting of the complete output spectrum (acronym PC) across the 50-ohm resistor present between node 6 and the ground node (card no. 9). By not including AP on the option card, the printing of the responses at all extracted ports was suppressed; instead, only the responses across the 50-ohm resistor and the 0.1 ohm resistor are printed. The transistor parameters used in the example are listed on the computer print-out.

Referring to the computer printed output, we note that all the userspecified information has been listed. A description of the augmented linear network, which is formed after the linear parts of the nonlinear elements have been lumped with the existing linear network, is also listed. In the present examples, six ports were extracted as shown by the port assignment description. The open-circuit impedance matrix is therefore of dimension 6x6. The pole-residue information (see eqn. 4-8) for each of the entries of this matrix is also provided. The transfer function and the output voltage values for the parious orders and frequency combinations have also





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been listed. Finally, the output spectrum across port 3 (node pair 6-D) has been printed and plotted. The total execution time for this example on the CDC 6500 computer is approximately 4.8 seconds.

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 Data Preparation for Example 4-1

Fig. 4-6.

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Figure 4-7. Data Cards for Example 4-1

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EIGENUALUE -3.387842+12+J 0 -8.715533+10+J 1.511072+09+J -5.306042+07+J 0 -1.844732+06+J 0 -6.161552+04+J	EIGENUALUE -3.387845+12+J -3.31553E+10+J -3.71553E+10+J -1.511072+09+J -5.30604E+07+J -5.30604E+07+J -6.16155E+04+J	EIGENUALUE -3.38784E+12+J -3.38784E+12+J -8.71552E+10+J -1.51107E+09+J -5.30504E+07+J -1.844702F+05+J -6.16155E+04+J	EIGENUALUE -3.28784E+12+J 0 -3.71552E+10+J 0 -1.51107E+09+J -5.30504E+07+J 0 -1.844722+05+J 0 -6.151552+04+J	EICENUALUE -3.38784E+12+J -3.31553E+12+J -3.71553E+10+J -1.51107E+03+J -5.30504E+07+J -1.844722+05+J -3.16155E+04+J -3.16155E+04+J	EIGENUALUE -3.337845+12+J 0 -3.715552+10+J 0 -1.511075+09+J 0 -5.305045+07+J 0 -5.161555+04+J 0 -5.161555+04+J
CCUNSTANT= 0 2(5, 1): RESIDUE 6.40568E+10+J -6.52321E+10+J -1.21920E+10+J 1.31902E+10+J 1.29165E+08+J -1.90917E+07+J	CONSTANT= 0 2(5, 2): RESIDUE 8.67807E+10+J -6.23161E+07+J 1.080042+08+J -2.5885E+07+J -2.5885E+07+J -2.5885E+07+J -2.5885E+07+J -2.58056E+04+J	CONSTANT= 0 2(5, 3): RESIDUE 6.42421E+10+J -5.88532E+09+J -5.78403E+10+J -5.78403E+10+J -5.19457E+08+J 6.80094E+04+J 8.80094E+04+J 2.56242E+06+J	CONSTANT= 0 2(5, 4): RESIDUE -2.55091E+08+J -1.57082E+10+J 1.51225E+10+J 1.51222E+10+J -5.6701EE+07+J 9.16425E+08+J	CONSTANT= 0 Z(5, 5): RESIDUE -2.22995E+10+J -5.80464E+09+J -4.214495+10+J -4.214495+10+J -4.1.55924E+10+J -1.55924E+10+J -1.03221E+09+J	CCDNSTANT= 0 2(5, 5): RESIDUE 1.853354.08+J 5.934465+10+J -4.55451E+10+J -1.233226+10+J 8.2253252+10+J -1.03551E+09+J

EIGENUALUE -3.287345+12+J -3.287345+12+J -3.11972+03+J -1.511972+03+J -1.314725+03+J -1.344725+03+J -0.151555+04+J	5165NURLUE -2.337345+12+1 -3.71553510+1 -1.511075495+1 -1.841775495+1 -1.844775495+1 -5.205945454541 -6.151555495+1	0 -3.287842+125 -3.287842+12+ -3.7185252+12+ -1.51192496+ -1.51192496+ -1.814725+53+ -1.814725+53+ -1.81412868+53+	6 -3.237345+12+ -3.237345+12+ -3.715525+15+1 1.511015+03+1 -5.0590515+03+1 -1.311015+03+1 -1.311035+03+1 -1.315135+03+1 -3.131535+04+1	<pre>EIGENUALUE -3.23704E+12+1 -3.71553E+10+1 -1.51107E+03+1 -1.5130504E+03+1 -5.30504E+07+1 -1.84473E+07+1 -1.84473E+05+1 0 -5.16155E+04+1</pre>	EIGENUALUE -3.38784E+12+J -3.71553E+10+J -1.511072+09+J -1.511072+09+J -1.5310472E+07+J -1.84473E+07+J -1.6155E+04+J -6.16155E+04+J
CCNSTANT= 2(G, 1): RESIDUE -5.325215+08+J 6.654055+11+J 1.307525+10+J 1.307525+10+J 1.175925 +03+J -1.903172+07+J	CCNN5TANIT= 2(G, 2): 2(G, 2): -7.215547+03+J 6.563152+03+J 1.103162+06+J -2.557322*05+J -2.55732*05+J 3.554315*04+J	CONSTANT= 0 2(G. 3): -5.340525408*4 -5.340525408*4 -5.3405252*10*4 -5.1945052*10*4 -5.1957052*10*4 -5.295705705*4 -5.26240544 2.56240544	0 0 0 0 0 0 0 0 0 0 0 0 0 0	CCR:STANT= 5 2(6, 5): RESTINS 1.852824-03+J 5.930005+10+J -4.204745+10+J -1.542775+10+J -1.032215+05+J -1.032215+05+J	CDNSTANT⇒ Z(G, G): PESIDUE -1.54089E+06+J -1.54089E+06+J -1.54089E+10+J -4.66628E+10+J -1.28205EF+10+J 7.581077=407+J -1.03361E+09+J

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0 FIRST ORDER:

FREQUENCY( 1 )= 2.500E+06 TRANSFER FUNCTION

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OUTPUT UOLTAGE

| PORT<br>NO    | REAL                        | IMAGINARY                   | MAGNI TUDE                 | 20LDG MAG                   | REAL                        | IMAGINARY                    | MAGNI TUDE                 | PHASE             |
|---------------|-----------------------------|-----------------------------|----------------------------|-----------------------------|-----------------------------|------------------------------|----------------------------|-------------------|
| ุณฑ           | 1.00336E-02<br>-4.29645E+00 | -1.32885E-03<br>7.73651E-01 | 1.01212E-02<br>4.36555E+00 | -3,989546+01<br>1,28008E+01 | 1.00336E-02<br>-4.29645E+00 | -1.32885E-03<br>7.73651E-01  | 1.01212E-02<br>4.36555E+00 | -7.54<br>169.79   |
| FIRST ORDER:  |                             | FREQUENCY( 2)=              | 3.000E+06                  | ΗZ                          |                             |                              |                            |                   |
|               |                             | TRANSFER                    | FUNCTION                   |                             |                             | OUTPUT VOLT                  | AGE                        |                   |
| PORT          | REAL                        | IMAGINARY                   | MAGNITUDE                  | 2010C MAC                   | REAL                        | IMAGINARY                    | MAGNI TUDE                 | PHASE<br>DEG      |
| იი            | 9.77794E-03<br>-4.16119E+00 | -1.94875E-03<br>1.07990E+00 | 9.97024E-03<br>4.29904E+00 | -4.00259E+01<br>1.26674E+01 | 9.77794E-03<br>-4.15119E+00 | -1.94875E-03<br>-1.97990E+00 | 9.97024E-03<br>4.29904E+00 | -11.27            |
| FIRST ORDER:  |                             | FREQUENCY( 3 )=             | 3.500E+0G                  | HZ                          |                             |                              |                            |                   |
|               |                             | TRANSFER                    | FUNCTION                   |                             |                             | מעדפעד טמבד                  | AGE                        |                   |
| PORT<br>NO    | REAL                        | Imaginary                   | MAGNITUDE                  | 20LDG MAG                   | REAL                        | IMAGINARY                    | MAGNITUDE                  | PHASE<br>DEG      |
| იო            | 9.47540E-03<br>-4.00289E+00 | -2.463255-03<br>1.33551E+00 | 9.79034E-03<br>4.21984E+00 | -4.01840E+01<br>1.25059E+01 | 9.47540E-03<br>-4.00289E+00 | -2.463252-03<br>1.33561E+00  | 9.79034E-03                | -14.57<br>-181.55 |
| SECOND ORDER: |                             | FREQUENCY( 1, 1             | )= 5,000E+(                | 36 HZ                       |                             |                              |                            |                   |
|               |                             | TRANSFER                    | FUNCTION                   |                             |                             | αυτΡυτ νοιτι                 | AGE                        |                   |
| PCRT<br>140   | REAL                        | IMAGINARY                   | MAGNITUDE                  | ZOLDG MAG                   | REAL                        | IMAGINARY                    | MAGNITUDE                  | PHASE<br>DEG      |
| ຎຓ            | 2.055745-02<br>-9.64119E+00 | -1.105855+00                | 2.05397E-02<br>3.70441E+00 | -3.37059£+01<br>1.97394£+01 | 1.02837E-02<br>-4.82059E+00 | 8,63346E-04<br>-5.52945E-01  | 1.031995-02<br>4.852202+00 | 4.80<br>-173.45   |

47-177.89

i.729835-04 2.107945-02 -3.653595-01 9.94243E+00

2.10787E-02 -9.93577E+00

1.725335-04 2.10794E-02 ~3.35228E+01 -3.65355-01 9.9424E+00 1.99439E+01

2.10787E-02 -3.93577E+00

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FPEQUENCY/ 1. 3 )= 6.000E+06

TRANSFER FUNCTION

OUTPUT VOLTAGE

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PHASE DEG

MAGNITUDE

IMAGINARY

REAL

20LOC MAG

MAGHITUDE

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PEAL

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FREQUENCY( 1, 2)= 5,500E+06

SECOND DRDER:

TRANSFER FUNCTION

OUTPUT VOLTAGE

| PHASE<br>DEG | -3.55<br>177.95                             |                           | PHASE<br>DEG     | 00                                           |                             | PHASE<br>DEG | 22 - 2-1<br>23 - 2-1                              |                                       | Line<br>Line<br>Line<br>Line | 000<br>000<br>11                                             |                             | FRASE<br>TEG |                             |                         | PHASE                                                                                       |                                       |
|--------------|---------------------------------------------|---------------------------|------------------|----------------------------------------------|-----------------------------|--------------|---------------------------------------------------|---------------------------------------|------------------------------|--------------------------------------------------------------|-----------------------------|--------------|-----------------------------|-------------------------|---------------------------------------------------------------------------------------------|---------------------------------------|
| MAGNITUDE    | 2.13931E-02<br>1.01176E+01                  | JGE                       | MAGNITUDE        | 3.058222-03<br>6.609062-11                   | AGE                         | MAGMITUDE    | 1.073125-02<br>6.075245+00                        | 1901                                  | MAGNITUDE                    | E.171781-08<br>E.171781-08<br>1.0084781-08                   | TAGE                        | EGUT TUBE    | 5.61300E+00                 | LTAGE                   | MAGNITUDE                                                                                   | · · · · · · · · · · · · · · · · · · · |
| IMAGINARY    | -1.329655-03<br>3.603222-01                 | סחדפעד טמבדר              | <b>VARYIZAMI</b> | 00                                           | 0UTPUT VOL7                 | YAANTEAN!    | -7.700001-04<br>-7.100001-04<br>0.100001-01       | כטידטעד אמב                           | Acd: 15441                   | -0.100340+03<br>-0.100340+03<br>-1.204040+00                 | 00: 100-                    | TMACT HAPY   | 4.925495-03<br>-2.303342+00 | 0UTPUT UO               | TMAGINARY                                                                                   | •                                     |
| PEA'.        | 2.13517E-02<br>-1.01112E+01                 |                           | FEAL             | 3.058226-03<br>6.609065-11                   |                             | - HEE        | 1.070539-02<br>-5.070539-02                       |                                       | ិតខ្មែ                       | 년.14000001-12<br>1.00001-02<br>1.00004-02                    |                             | PEA.         | 1.14977E-02<br>-5.11863E+00 |                         | PEAL                                                                                        | •                                     |
| 20LCG MAG    | -3.33945E+01<br>-3.33945E+01<br>2.01015E+01 | 42                        | 2010G MAG        | -5.02905E+01<br>-2.03597E+02<br>-2.03597E+02 | S H2                        | 20100 1140   | 10+11000000.01<br>10+11000000.01<br>10+11000000.0 | с<br>Г                                | 2070C MP2                    |                                                              | 05 HZ                       | 20105 MAG    |                             | 0<br>0                  | 20LOG MAG                                                                                   | • • • • • • • • • • •                 |
| MOGNITURE    | 2.13931E-02                                 | L )= C<br>FUNCTION        | MAGNITUDE        | 3.0532225-03<br>5.60906E-11                  | 2 )= 5.0035+0<br>• FuncTION | ECHTINO SM   | 10+102251.15.                                     | 2 - 5 6.5302 40<br>2 FUNCTION         | 300114084                    | 2.171735-02<br>1.023475+01                                   | -1)= 5.0005+<br>ER FUNCTION | MAGHITUDE    | 1.250335-02<br>5.513002+00  | 2 )=<br>ER FUNCTION     | MAGNITUDE                                                                                   | •                                     |
|              | 10-23252-01<br>                             | FREDUENCY( 11<br>TRANSFER | AUGNIOGHI        | ය <i>ය</i>                                   | FPECUENCY' 2.<br>TRANSFEP   | 2.201194311  | 4.078528401                                       | FISHER TO ALL B.                      | (27) 1120m                   |                                                              | FPECLENCK 2.                |              | 4.925:55-03                 | FPEQUENCIAL 2<br>TRANSF | 1.2641DE~I                                                                                  | •                                     |
|              | 2.125175-02<br>2.125175-02<br>10.11255-02   |                           | PTAL             | 3.050221-03<br>6.050221-03                   |                             | Je Di        |                                                   | · · · · · · · · · · · · · · · · · · · | i<br>L                       | 100000<br>100000<br>1000000<br>1000000<br>1000000<br>1000000 |                             |              |                             |                         | 1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1 |                                       |
|              |                                             | SECOHD ORDER:             |                  |                                              | SECOND C2DER                |              |                                                   | ರ್<br>ಕ್ಷದ್ರೇ ೧೯೮೧                    |                              | ្លែ្ល លៃ<br>ល្អ ៖<br>ល្អ ៖                                   | secore area                 | 1            |                             | 3<br>550040 080         | Haco                                                                                        |                                       |

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| c                            | 0             |            |            | PHASE     | DEG                         | 163.95         |             |                   | PHASE<br>DEG                 | 12.79<br>-165.94                  |          |            | PHASE<br>DEG                | 23 <b>.62</b><br>-153.35   |            |               | PKASE<br>DEG                | 00                         |               |               | FRASE<br>DEG<br>-51.04<br>130.25                         |
|------------------------------|---------------|------------|------------|-----------|-----------------------------|----------------|-------------|-------------------|------------------------------|-----------------------------------|----------|------------|-----------------------------|----------------------------|------------|---------------|-----------------------------|----------------------------|---------------|---------------|----------------------------------------------------------|
| 2.96590E-03                  | 6.40957E-11   |            | 191        | MAGNITUDE | 1.093755-02                 | 5.204242+00    | UCC<br>UCC  |                   | MAGNITUDE                    | L. €6335535 ÷03<br>6. 8335535 ÷00 |          | 122        | MAGNITUDE                   | L.20016E-02<br>5.42553E+00 | Ļ          | 1             | MAGNITUDE                   | 2.857025-03<br>6.175055-11 | 1.1           |               | 1455711011                                               |
| o                            | 0             |            |            | IMAGINARY | -2.341055-03                | 9.55720E-01    | 011PUT UN 7 | T MAN TO AN       | S DESTARTES                  | -1.51455E+00                      |          |            |                             | -2.263412÷00               |            |               | ABBAESUNI                   |                            | מטזפטד עמיזהמ | A EUX - EUX I | 00-32220 S                                               |
| 2,96590E-03<br>6,405675-11   |               |            |            | REAL      | 1.070455-02                 |                |             | 1<br>E T QI       | 1.251175-02                  | -6.045235400                      |          | 5          | 1.107655-02                 | -4.531365+00               |            |               | 1957.53.54.05               | 6.176025-11                |               | TUE!!         | 1.057055-n2<br>1.057055-n2<br>0.16'67500                 |
| -5.05569£+01<br>-2.03863£+02 | 06 H2         |            |            |           | -3.31851E+01<br>2.03478E+01 | JS HZ          |             | 20LOG MAG         | -3.71577E+01                 | 10+510000.1<br>5 H2               |          | 20-05 MAG  | -3.33503E+01                | 1.453355*01<br>  HZ        |            |               | 10+32332+01                 | -2.011882+02<br>03 HZ      | 1             | 20102 KH2     | 2.34:552401<br>3.003102405<br>3.112                      |
| 2.95590E-03<br>6.40957E-11   | 2 /= 7.000E+  | R FUNCTION | MAGNI TUM= |           | 2.19151E-02<br>1.04083E+01  | 1 )≈ 1.000£+0  | FUNCTION    | MAGNI TUDE        | 1.335325-02<br>6.925525-02   | 2)= 3.0005+0                      | FUNCTION | ECUT INQU  |                             | )= ()                      | FU:12T10:1 | 100111109U    | 5.1357-03                   | 1)= 7.5003+                | 1.5130.45     | ECUTERS1      | 3.103575-02<br>3.103575-02<br>2.133575-01<br>2.133575-02 |
| 00                           | FREQUENCY( 3, | TRANSFE    | IMAGINARY  |           | -4.58217E-03<br>1.93344E+00 | FREQUENCY( 3,- | TRANSFER    | <b>VAGNI DAMI</b> | 3.055142-03<br>-1.514557-400 | FREQUENCIA 3,-6                   | TRANSFER | Augus Seme | 4.344053403<br>-2.833117×00 | FREQUENCY( 3,-3            | TRANSFER   | A 20112 Sette | 6                           | . ಕ್ರಾಂಗದ್ರಾರ. ಕ್ರ         | A CENSUL      | ABUNEBUNE     | 5,280172-02<br>2,480788-02<br>2,480788-02<br>2,480788-02 |
| 2.255905-03<br>6.40957E-11   | å.            |            | rea.       |           | Z.140915-02<br>-1.021525≯01 | •              | •           | L'SEA             | 1.251175-02<br>-S.045222+00  | <u>.</u> .                        |          | LEN.       | 1.107855-02<br>             |                            |            | 1991          | 2.057075-00<br>6.11-0025-11 | 1.2                        |               | LEN.          |                                                          |
| លព                           | SECOND ORDS   |            | PCRT       |           | ນຕ                          | SECOND DRDER   |             | P0RT<br>110       | eo co                        | כבכסאם מגמבע                      |          | 7037       | ຸ<br>ເນ ຕາ                  | בבכסום כמתבה:              |            | FC.7.<br>1.1  | 01:2                        | יטבעט פעזאנ                |               | F037          |                                                          |

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-64.59 4.74 19.77 -153.11 -58.07 21.57 -156.51 PHASE DEG PHASE PHASE PHASE DEG PHASE DEC PHASE DEG 5.164585-02 2.3645iE÷01 3.49271E-02 1.58527E+01 2.65050E-02 -4.254132-02 5.01231E-02 -1.30274E+01 1.998265+01 2.38541E+01 4.9496855-02 2.358645+01 2.93906E-02 1.32276E+01 MAGNI TUDE MAGNITUDE MAGNI TUDE MAGNITUDE MAGNITUDE MAGNI TUDE OUTPUT VOLTAGE DUTPUT VOLTAGE OUTPUT VOLTAGE DUTPUT UOLTAGE DUTPUT VOLTAGE DUTPUT UD\_TAGE -4.470555-02 2.111325÷01 1.18150E-02 -5.91125E+00 4.265915-03 -2.840736+00 1.08051E-02 -5.271605+00 IMAGINARY IMAGINARY IMAGINARY IMAGINARY IMAGINARY IMACINARY 2.123545-02 -1.05144E+01 5.145925-02 -2.3473355+01 3.286765-02 -1.470532+01 2.73323E-02 -1.21317E+01 REAL FEAL REAL REAL FER REAL 3.53412E-02 -5.67217E-02 6.53303E-02 -2.35005E+01 -1.725392E+01 2.55435E+01 3.00500E+01 -2.35097E+01 2.99520E+01 5.689282-03 6.235105-02 -2.32405E+01 -3.707542+00 3.15258E+01 2.99736E+01 -2.650085+01 2.49284E+01 20LOC MAG 20LOG MAG 20LOG MAG ZOLOG MAC 20LOG MAC ZOLOG MAG ¥ ¥ ЧЧ FREQUENCY( 1, 1,-2)= 2.0005+05 HZ ¥ FREQUENCY( 1, 1, 3 )= 8.500E+0S FREQUENCY( 1, 2, 2 )= 8.500E+05 FREQUENCY( 1, 1,-1 )= 2.500E+0S FREQUENCY( 1, 1,-3 )= 1.500E+05 -5.551222-02 5.59557E-02 2.81505E+01 3.14485E+01 1.575477-02 4.655345-02 -2.831655+00 2.113535+01 1.440525-02 3.91874E-02 -7.023805+00 1.75367E+01 MAGNITUDE **MASNI TUDE** MAGNI TUDE MAGNI TUDE MAGNI TUDE MAGNI TUDE TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION **YAAGINARY** IMAGINARY **VRANIDAMI** IMAGICAPY **YARNIDAMI** IMAGINARY 2.831515-02 -1.401925+01 6.555555-02 -0.120343+01 -:-617558+01 4.832358-02 -1.501245401 REAL L'UEU REAL REG. 1919. PER. THIP: CRDER: THIRD ORDER THIRD ORDER: THER CREEK THIPD GREER 202 02 02 00 1505 1505 문문 이어

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| -65.11<br>115.96            |                 |             | PHASE<br>DEG | -71.61<br>109.35             |                 |              | PHASE-<br>DEG | -6.52<br>175.68              |                 |             | PHASE<br>DEG | 9.32<br>-168.43              |                 |             | PHASS<br>DEG | 18.40<br>-159.45             |                 |             | PHASE<br>DEG | -78.10<br>102.76                            |                 |
|-----------------------------|-----------------|-------------|--------------|------------------------------|-----------------|--------------|---------------|------------------------------|-----------------|-------------|--------------|------------------------------|-----------------|-------------|--------------|------------------------------|-----------------|-------------|--------------|---------------------------------------------|-----------------|
| 4.97134£-02<br>2.36896E+01  |                 | AGE         | MAGNITUDE    | 9.80177E-02<br>4.67553E+01   |                 | AGE          | MAGNI TUDE    | 9.38334E-02<br>4.321565+01   |                 | AGE         | MAGNITUDE    | 8.457655-02<br>3.870235+01   |                 | 306         | MAGNITUDE    | 6.25324E-02<br>2.85762E+01   |                 | JC2         | MAGNI TUDE   | 4.824575-02<br>2.303835+01                  |                 |
| -4.50949£-02<br>2.12995£+01 |                 | ουτΡυτ νοιτ | IMAGINARY    | -9.301455-02<br>4.411962+01  |                 | ουτρυτ νοιτί | IMAGINARY     | -1.06514E-02<br>3.25363E+00  |                 | מעדפעד טמבת | IMAGINARY    | 1.37027E-02<br>-7.72873E+00  |                 | DUTPUT VOLT | Imaginary    | 1.927765-02<br>-1.002432+01  |                 | תוסט דטקדנם | IMAGINARY    | -4.720525-02<br>-4.720525-02<br>2.245955+01 |                 |
| 2.09254E-02<br>-1.03696E+01 |                 |             | REAL         | 3.09158E-02<br>-1.54905E+01  |                 |              | , REAL        | 9.323155-02<br>-4.309292+01  |                 |             | REAL         | 8.34592E-02<br>-3.7522EE+01  |                 |             | REAL         | 5.976345-02<br>-2.676035+01  |                 |             | REAL         | 9.546535-03<br>-5.087395+00                 |                 |
| -2.35718E+01<br>2.99899E+01 | C+05 HZ         |             | ZOLOG MAG    | -2.36957E+01<br>-2.98757E+01 | 2H S0+3         |              | ZOLOG MAG     | -2.40742E+01<br>-2.91910E+01 | 2H S0+3         |             | ZOLDG MAG    | -2.497635+01<br>-2.823295+01 | ZH 50+3         |             | ZOLOG MAG    | -2.753745+01<br>-2.552332+01 | ZH S0+3         |             | ZOLOC MAG    | -2.333205+01<br>-2.374785+01<br>2.374785+01 | 24 SO+3         |
| 6.62846E-02<br>3.15861E+01  | · 3)= 9.000     | FUNCTION    | MAGNI TUDE   | 6.53452E-02<br>3.11733E+01   | 1)= 3.000       | FUNCTION     | MAGNITUDE     | 6.25589E-02<br>2.83104E+01   | 1,-2)= 2.500E   | FUNCTION    | MAGNITUDE    | 5.62244E-02<br>2.52015E+01   | ·               | FUNCTION    | MAGNITUDE    | 4.132835-02<br>1.505035-01   | t 3)= 9.500E    | FUNCTION    | HAGHT TUBE   | 5.432755-02<br>3.071775-02                  | 1-1 )= 3.300    |
| -6.01266E-02<br>2.83934E+01 | FREQUENCY( 1, 2 | TRANSFER    | Imaginary    | -6.200365-02<br>2.94131E+01  | FREQUENCY( 1, 2 | TRANSFER     | IMAGINARY     | -7.100935-03<br>-7.100935-03 | FREDUENCY( 1. 2 | TRANSFER    | IMAGINARY    | 9.135122-03<br>-5.152432+00  | FREDUENCYC 1, 2 | LRANSFER    | LUUNIDEWI    | L.223175+02<br>-S.602345+00  | FPEDLENCYC 1, 3 | TRANSFER    | ACCHESEME    | -5.801585+02<br>-2.83351:2401               | FIEDUENCIA 1. 3 |
| 2.79005E-02<br>-1.38261E+01 |                 |             | REAL         | 2.05105E-02<br>-1.032705+01  |                 | •            | REAL          | 6.215455-03<br>-2.872355+03  |                 |             | real         | -2.52355-02<br>-2.523155-02  |                 |             | LTNE         | 3.504225-02<br>-1.703025+01  |                 |             | LEAL         | 1004333002 F                                |                 |
| លក                          | THIRD ORDER:    |             | PORT<br>NO   | ູດເຕ                         | THIRD ORDER:    |              | PCRT<br>NO    | ຸດາມ                         | THIRD CRDER:    |             | РОRТ<br>1:0  | ຸດເຕ                         | THIRD ORDER:    |             | 001<br>1004  | nın.                         | THIP3 CR257:    |             | 7037<br>110  | 000                                         | בוויים כיתבתי   |

-73.62 102.24 8.17 -169.62 -72,13 -10.05 -2.44 179.60 PHASE DEG 72620 DEG PHASE DEG 5050 5050 PHASE PHASE DEG 7.70211E-02 2.523725+01 7.255505-02 3.25907E+01 -4.748695-02 4.843975-02 2.280435\*01 2.313085\*01 -1.601522-02 9.178145-02 5.817652+00 4.253445+01 MAGNITUDE MAGNITUDE MAGNI TUDE PAGNE TUPE MAGNI TUDE MAGNITUDE DUTPUT UD\_TAGE 0.7PU7 'J0L AGE DUTPUT UDLIAGE DUTPUT UDLTAGE OUTPUT VOLTAGE -3.131065-03 1.186285-01 1.054352-02 -6.343535+00 -1.531245-02 -1.531245-02 7.407125+00 **VARY I DARI** IMAGINARY IMAGINARY THESIPPRY IMAGINARY **VEGNIDAMI** 5.033942-07 +2.525952+00 5.560465-03 -4.554755+00 -3.358955-02 -3.3850555-02 -3.455062+02 9.037265-02 -4.213465+01 PER 7.5A'. REAL REAL REAL REAL 1,20025-12 -3.001555-02 3.450535-02 -2.379/22+01 -2.530725-0 0.010035-01 0.051115-01 2.972355+01 -2.617772+01 2.707985+01 7.625252-03 5.134745-02 -2.578355+01 -4.202325400 2.343155+01 2.741825+01 5.051356-02 -2.0353342+01 3.000355+01 2.031205+01 6.118755-02 -2.425576401 2.8055225401 2.905306401 20LCG MAG 20LOG MAS 20106 743 2010G MAG 20LOG MAG 2010G MAG ¥ Η FTECUEUCYC 2, 2, 2 )= 9,000E+05 HZ FTEQJENT / 2, 2, 2 )= 9.500E+05 112 FREQUENCY( 1, 3,-2)= 3,0005+05 HZ 3.500E+05 2.500E+0S 4.01040E-02 2.253332E+01 MAGIN TUBE PAGNI TUDE **MAGNITUDE MAGNI TUDE** MAGENT JDE MAGNI TUBE TPANSFEP FUNCTION TRAISFER FUNCTION TRANSFED FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION FREQUENCY( 1, 3,-3 )= FPECUENC/( 2, 2,-1 )= 12001.5001 -1.057955-02 -1.872445+00 -2.037285-03 7.908572-02 adul Sunt **YRACICARY** ANANTZAMI INAGENARY **ANANIDAMI** 5,005535-02 -2,0105535-02 4.205935-02 +2.253372+01 6.024341-02 -2.80833€∻01 1,9 E U 1291 REN. THEN CPDED: HIT COULD THET COLOR THIRD ORDER: THIRD ORDER: Г**а**Са 09. 1222 ູ່ລະບ Egg 101 101 101 P02 50 លក

OUTPUT UDLIAGE

TRANSFER FUNCTION

15.59 -162.16 -176.39 -85.03 93.63 -24.72 157.33 -20.29 PHASE DEG PHASE PHASE PHASE PHASE 4.761405-02 2.27553E+01 4.29685E-02 1.98870E+01 5.06937E-02 2.33733E+01 3.37340E-02 1.54285E+01 8.35092E-02 3.88597E+01 MAGNITUDE MAGNITUDE MAGNI TUDE MAGNITUDE MAGNITUDE OUTPUT VOLTAGE OUTPUT VOLTAGE OUTPUT VOLTAGE OUTPUT VOLTAGE OUTPUT VOLTAGE -4.743835-02 2.264395+01 -3.49209E-02 1.49438E+01 7.10579E-04 -1.49035E-02 6.19137E+00 9.06564E-03 -4.72695E+00 IMAGINARY IMAGINARY IMAGINARY IMAGINARY IMAGINARY 4.08610E-03 -2.25408E+00 4.03011E-02 -1.88987E+01 3.24930E-02 -1.46866E+01 7.58580E~02 -3.58715E+01 5.06888E-02 -2.33411E+01 REAL REAL REAL REAL REAL -2.50871E+01 2.82682E+01 -2.34021E+01 2.98732E+01 -2.48382E+01 2.84702E+01 -2.69399E+01 2.62653E+01 -2.39455E+01 2.96406E+01 20LOC MAC ZOLOG MAG ZOLOG MAG 20LDG MAG 20LDG MAG ¥ ¥ ¥ ¥ ¥ FREQUENCY( 2, 3,-2 )= 3,500E+06 2.500E+06 FREQUENCY( 2, 3, 3 )= 1,000E+07 4.000E+06 FREQUENCY( 2, 2,-2)= 3.000E+05 6.75917E-02 3.11644E+01 5.56733E-02 2.59065E+01 5.72914E-02 2.65160E+01 1.20875E-02 4.49787E-02 -6.30260E+00 2.05713E+01 -6.32511E-02 6.34853E-02 3.01919E+01 3.03411E+01 MAGNITUDE MAGNI TUDE MAGNI TUDE MAGNI TUDE MAGNI TUDE TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION FREQUENCY( 2, 2,-3 )= FREQUENCY( 2, 3,-1 )= -2.32806E-02 9.96256E+00 9.474385-04 -1.63671E+00 -1.98713E-02 8.25516E+00 IMAGINARY IMAGINARY IMAGINARY IMAGINARY 5.44814E-03 -3.00544E+00 5.05720E-02 -2.39143E+01 4.33241E-02 -1.95821E+01 5.37348E-02 -2.51982E+01 6.75850E-02 -3.11214E+01 REAL REAL REAL REAL THIRD ORDER: THIRD ORDER: THIRD ORDER: THIRD ORDER THIRD ORDER: NO NO NO NO NO P03T P02T ิ่งค PORT เลต ູດທ

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-10.45

9.162345-02 4.24627E+01

-1.661265-02 6.10272E÷00

9.01048E-02 -4.20219E+01

-2,42817E+01 2,90383E+01

6.10823E-02 2.83085E+01

-1.10751E-02 4.06843E+00

6.006935-02 -2.801465+01

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IMAGINARY

REAL

PORT

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3.000E+05

FREDUENCY( 2, 3,-3 )=

THIRD CRDER:

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TRANSFER FUNCTION

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OUTPUT VOLTAGE

| PORT<br>NO   | าบริน                       | 1.20NISWI                   | HAGNI TUDE                 | ZOLOG MAG                    | REAL                        | IMAGINARY                   | MAGNI TUDE                 | PHASE<br>DEG     |
|--------------|-----------------------------|-----------------------------|----------------------------|------------------------------|-----------------------------|-----------------------------|----------------------------|------------------|
| ເມຕ          | 5.44314E-02<br>-2.42352E+01 | 5.235025-03<br>-3.401325+00 | 5.471455-02<br>2.521582+01 | -2.523805+01<br>-2.80335E+01 | 8.16922E-02<br>-3.74780E+01 | 7.83412E-03<br>-5.101992+00 | 8.20717E-02<br>3.78237E+01 | 5.51<br>-172.25  |
| THIRD ORDER: |                             | FREQUENCYC 3, 3             | 3, 3 )= 1.050E             | +07 HZ                       |                             |                             |                            |                  |
|              |                             | TRANSFER                    | ? FUNCTION                 |                              |                             | סטדפטד עסנדו                | AGE                        |                  |
| P02<br>N0    | LER.                        | IMAGINARY                   | RAGNITUDE                  | 20106 MAG                    | REAL                        | IMAGINARY                   | MAGNITUDE                  | PHASE<br>DEG     |
|              | -1.623245-03<br>4.350523-01 | -6.230055-02                | 5.23251E-02<br>2.33022E+01 | -2.41057E+01<br>2.94869E+01  | -4.020555-04<br>1.087665-01 | -1.557595-02<br>7.451405+00 | 1.55813E-02<br>7.45215E+00 | -91.50<br>89.16  |
| THIRD ORDER: |                             | FREQUENCY( 3, 3             | 3,-1 )= 4.500E             | +05 HZ                       |                             |                             |                            |                  |
|              |                             | TRANSFER                    | EUNCTION                   |                              |                             | סטדפטד טסבאו                | AG5                        |                  |
| PC27<br>NO   | TUEN                        | IMAGINARY                   | MAGNITUDE                  | 20LOG MAG                    | real.                       | IMAGINARY                   | EQUI TUDE                  | PHASE<br>DEG     |
| 0 M          | 4.600055-02<br>-2.301055+01 | -2.545455-02<br>1.153785+01 | 5.379235-02<br>2.51474E+01 | -2.533555+01<br>-2.30099E+01 | 3.512835-02<br>~1.673885+01 | -1.934095-02<br>3.690865÷00 | 4.03447E-02<br>1.88505E+01 | -29.46<br>152.56 |
| THIRD ORDER: |                             | FREQUENCYC 3. 3             | },-2)= 4.000E              | +05 HZ                       |                             |                             |                            |                  |
|              |                             | TRANSFER                    | EUNCTION                   |                              |                             | ουτρυτ νοιτι                | AGE                        |                  |
| 7527<br>011  | LEAL                        | ANDING THREE                | MAGNITUDE                  | 20LOG MAG                    | REAL                        | IMAGINARY                   | MAGNITUDE                  | PHASE<br>DEG     |
|              | 5.072455-02<br>-2.353015+01 | -2.233355-02<br>9.725445+00 | 5.55533E-02<br>2.59002E+01 | -2.50901E+01<br>-2.82551E+01 | 3.80434E-02<br>-1.75851E+01 | -1.717455-02<br>7.339835+00 | 4.17404E-02<br>1.94251E÷01 | -24.30<br>157.80 |
| THIRD ORDER: |                             | FREQUENCY( 3, 3             | 33 )= 3.500E               | :+06 HZ                      |                             |                             |                            |                  |
|              |                             | TRANSFER                    | PUNCTION                   |                              |                             | OUTPUT VOLT                 | AGE                        |                  |
| PCRT<br>NO   | REAL                        | <b>YARINARY</b>             | MAGNITUDE                  | 20LOG MAG                    | REAL                        | IMAGINGRY                   | MAGNITUDE                  | PHASE<br>DEG     |
| ຸດເດ         | 6.552205-02<br>-3.046395+01 | -3.13450E-03<br>2.92175E-01 | 6.55722E-02<br>3.04713E+01 | -2.365235+01<br>2.96778E+01  | 4.91985E-02<br>-2.28524E÷01 | -2.35095E-03<br>2.19131E-01 | 4.925465-02<br>2.285355+01 | -2.74<br>179.45  |

SINUSOIDAL STEADY-STATE OUTPUT RESPONSE AT PORT 3

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| PHASE<br>DEG       | -1.783E+02               | 1.735E+02<br>-1.735E+02<br>-1.779E+02<br>1.778E+02   | 0<br>1.7335+02<br>-1.5566+02                     |                                                                    | -1.550E+02<br>-1.555E+02<br>1.093E+02<br>1.025E+02   | 9.5682401<br>1.5755402<br>8.9162401<br>1.5265402    |
|--------------------|--------------------------|------------------------------------------------------|--------------------------------------------------|--------------------------------------------------------------------|------------------------------------------------------|-----------------------------------------------------|
| MAGNITUDE          | 1.088E+02<br>1.337E+02   | 1.231E+02<br>4.852E+00<br>9.942E+00<br>1.519E+01     | 1.919E-10<br>1.029E+01<br>1.104E+01<br>E 204E+01 | 6.2366+00<br>7.9836+00<br>2.3856+00<br>2.3856+01<br>4.7286+01      | 4.443E+01<br>1.323E+01<br>5.459E+01<br>4.617E+01     | 2.276E+01<br>5.828E+01<br>7.452E+00<br>1.886E+01    |
| IMAGINARY          | -2.242E+01<br>-4.037E+00 | 1.700E+01<br>-5.529E-01<br>-3.654E-01<br>5.789E-01   | 0<br>1.204E+00<br>-4.567E+00<br>0.775_0          | -1.51555-01<br>-1.51555+00<br>6.03885+01<br>1.9385+01<br>4.2415+01 | -1.5346+01<br>-5.2726+00<br>5.1536+01<br>4.5076+01   | 2.264E+01<br>2.228E+01<br>7.451E+00<br>8.531E+00    |
| REAL               | -1.054E+02<br>-1.336E+02 | -1.219E+02<br>-4.821E+00<br>-9.936E+00<br>-1.518E+01 | 1.919E-10<br>-1.022E+01<br>-1.005E+01            | -5.0435+00<br>-5.0435+00<br>-1.3035+00<br>-2.0835+01               | -4.147E+01<br>-1.213E+01<br>-1.802E+01<br>-9.992E+00 | -2.254E+00<br>-5.386E+01<br>1.088E-01<br>-1.674E+01 |
| FREQUENCY<br>HERT2 | 2.50E+05<br>3.00E+05     | 4.50E+05<br>5.50E+06<br>5.50E+06<br>6.00E+06         | 0<br>6.50E+06<br>5.00E+05                        | 7.005405<br>1.005405<br>7.505406<br>8.005406<br>8.505406           | 2.005+05<br>1.505+05<br>9.005+05<br>9.505+05         | 1.00E+07<br>4.00E+05<br>1.05E+07<br>4.50E+06        |

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TIME FOR FORMING ZOC(SEC) 1.1530 TIME FOR OBTAINING OUTPUT SPECTRUM(SEC) 3.6050 TOTAL EXECUTION TIME(SEC) 4.7580

\*\*\* P R A N C \*\*\* SEPTEMBER 1979 UERSION

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## Example 4-2: Two-Stage Tuned Amplifier Circuit

Consider the two-stage tuned amplifier circuit of Fig. 4-8. The input source comprises of two frequencies:

$$v_{r}(t) = \cos(2\pi \ 3 \ x \ 10^{6}t) + \cos(2\pi \ 3.25 \ x \ 10^{6}t)$$

The sequence of data cards used are shown in Fig. 4-9. In this example the frequency sweep capability (FS on the option card) offered by PRANC was used.

The computer printed output is similar to that for Example 4-1. The two transistors in the circuit account for six nonlinear elements. Altogether nine ports were extracted for the Volterra series analysis, two of which were the desired output ports.

The maximum number of frequency increments specified were five. Note that, as the frequency sweep is implemented, the set of input frequencies are printed before the transfer function and output voltage values. Considering the execution times, we note that the formation of the 9x9 opencircuit matrix took approximately 4 seconds on the CDC 6500 computer; the calculation and the printing of the transfer functions and output voltage values at the positive frequency values (approximately 90 points\*) required approximately 18 seconds. The entire program execution required less than 22 seconds.

<sup>\*</sup>The actual number of points is approximately 150, since transfer functions at negative frequencies are required in the calculations.



Figure 4-8. Circuit Diagram for Example 4-2

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Figure 4-9. Data Cards for Example 4-2

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EXAMPLE 4-2: THD-STAGE TUNED AMPLIFIER CIRCUIT

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> 2 USER REQUESTED OPTIONS: DEBUG PRINT-OUT: NO DEBUG PRINT-OUT: NO TRUO-INPUT CIRCUIT: NO STATE EQUATION PRINT-OUT: NO EIGENVALUES MODAL MATRIX PRINT-OUT: NO OPEN-CIRCUIT IMPEDANCE MATRIX PRINT-OUT: NO OPEN-CIRCUIT IMPEDANCE MATRIX PRINT-OUT: NO ALL EXTRACTED PORT OUTPUTS: NO

NETWORK DESCRIPTION:

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|          | CONTROL<br>BRANCH       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----------|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|          | ELEMENT<br>UALUE        | 8.3305-09<br>6.7155+03<br>3.3495+03<br>4.6505+02<br>1.1505-02<br>9.5305-07<br>1.1505-07<br>9.5305-07<br>1.1505-07<br>9.5505-07<br>1.7705-00<br>1.7705-01<br>9.9535+03<br>9.9535+03<br>9.9535+03<br>1.0005-11<br>1.2005-11<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01<br>1.2005-01005-010005-01005-0005-0005-00000000 |
|          | ELEMENT<br>TYPE         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|          | 01<br>10<br>10<br>10    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| ELEMENTS | FROM<br>NODE            | 4 ນເນ ຫ ພ ທ ທ ທ ທ ທ ທ ທ ທ ທ ທ ທ ທ ທ ທ ທ ທ ທ ທ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| LINEAR ! | <b>ERANCH</b><br>NUMBER | →៨យលឲ∽∞១ដឹជដីដូរិតីឆក្ខ<br>2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

## TRANSISTOR PARAMETERS:

| MU= .348<br>HFEMAX= 8.20<br>Γ≠2= 5 910F-08  | C3= 1.500E-12 |
|---------------------------------------------|---------------|
| UCBO=140.000<br>A= 125<br>C IE= 3400F-10    |               |
| UCB= 9.300<br>ICMAX= 1.500E-01<br>PFF= 1.00 | RC= 6.330E+05 |
| N= 4.600<br>IC= 3.700E+03<br>K= 2.450F-11   | RB= 10.100    |

## UCB= 9.600 ICMAX= 2.000E-02 REF= 1.00 RC= 2.000E+05 TRANSISTOR PARAMETERS: N= 4.500 IC= 3.700E-03 K= 1.400E-12 RB= 90.000

Sec.

MU= .086 HFEMAX= 51.40 C≭2= 7.500E-09 C3= 0

UCBO= 50.000 A= .300 CJE= 2.500E-11 C1= 0

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NONLINEAR ELEMENTS

|                      | ß≈ 3.8988E+01    | 120= 2.7446E+00<br>130= 3.4980E+01<br>12= 5.2334E-08            | 13= 4 <b>.</b> 8284E-15 | 13= 3.4330£+01    | A20= 2.67265400<br>A30= 3.3741E+01<br>A12= 7.1807E-05         | A3= 4.63182-16   |
|----------------------|------------------|-----------------------------------------------------------------|-------------------------|-------------------|---------------------------------------------------------------|------------------|
| NTS<br>              | 3.0862E+00 A     | <pre>~ 7.0034E-09 A<br/>~ 2.7039E-07 A<br/>~ 5.1950E-06 A</pre> | - <b>-2.</b> 0207E-13 f | = 2.7174E+00 f    | I= 1.0334E-06 f<br>I= 3.9331E-05 f<br>I= 7.4643E-04 f         | = -2.0009E-14    |
| OLYNOMIAL COEFFICIE  | = 1.6286E-01 A2= | 0= 1.42855-01 A01<br>12= 1.35555-09 A11<br>13= 1.25355-10 A21   | = 1,1275E~11 A2=        | I= 1.4340E-01 A2= | 10= 1.4083E-01 A01<br>02= 1.8866E-07 A11<br>03= 1.6457E-03 A2 | 1= 1.1525E-12 A2 |
| CONTROL P<br>(1) (2) |                  | 25<br>24<br>26<br>26<br>26<br>26<br>26                          | E                       | ē                 | 31 30<br>30<br>30<br>30<br>30<br>30                           | Œ                |
| TYPE                 | 2                | E E                                                             | Ĵ                       | Ĕ                 | Ø                                                             | ų                |
| 10<br>MODE           | : (              | വങ                                                              | U                       | <b>"</b> "        | ) <del>-</del>                                                | 1                |
| FROM                 | •                | 9 N                                                             | ŕ                       | -                 | - a                                                           | N                |

SOURCE INFORMATION:

|  | £ | 10 |  | IMPEDANCE | 5.000E+01<br>AMPLITUDE | R<br>PHASE ( DEG |
|--|---|----|--|-----------|------------------------|------------------|
|--|---|----|--|-----------|------------------------|------------------|

MAXIMUM NUMBER OF INCREMENTS= FREQUENCY SHEEP TYPE: LIN

4

|            | 5001201<br>58247801<br>5600000000000000000000000000000000000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NOLI       | ELETENT<br>UALUE<br>UALUE<br>8.3305-09<br>5.9405-10<br>1.1535-12<br>5.9405-11<br>9.5005-11<br>1.5005-11<br>1.5005-11<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12<br>1.5005-12005-10005-10005-10005-10005-10000000000 |
| RK DESCRIP | REALER<br>TYPE<br>TYPE<br>TYPE<br>TYPE<br>TYPE<br>TYPE<br>TYPE<br>TYPE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| A NETHON   | 10000000000000000000000000000000000000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| LINER      | жи<br>рас:<br>-4 Фили 4 иг чг г обраи<br>- 4 Фили 4 иг чг г обраи                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| RUGMENTED  | RABACH<br>NUMBACH<br>NUMBACH<br>NUMBACH<br>12<br>12<br>12<br>12<br>12<br>12<br>12<br>12<br>12<br>12<br>12<br>12<br>12                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

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|                                                                        |                                                                                                              |                                | PHASE<br>DEG<br>                          |
|------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|--------------------------------|-------------------------------------------|
|                                                                        |                                                                                                              | JCE .                          | MAGNI TUDE<br>3.40204E-02<br>4.08273E-02  |
|                                                                        |                                                                                                              | OUTPUT VOLTA                   | IMAGINARY<br>-1.974495-02<br>-1.54311E-02 |
|                                                                        |                                                                                                              |                                | REAL<br>-2.77042E-02<br>-3.77988E-02      |
|                                                                        |                                                                                                              | ¥                              | 20LOC MAC<br>-2.936526+01<br>-2.78106+01  |
| <b>e ç e ç e e e e e e e e e e e e e e e e</b>                         |                                                                                                              | 3.000E+06<br>UNCTION           | MAGNITUDE<br>3.402046-02<br>4.03273E-02   |
| RRRRRRRRRRRRRRRRRRRRRRRRR<br>RRRRRRRRRRR                               |                                                                                                              | Freguency( 1 )=<br>Transfer Fi | IMAGINARY<br>-1.974495-02<br>-1.543115-02 |
| พพงพนี่-เวี่หนดมัดตีอหดหหตดหน่าย<br>ตองออนตีดอตวีออออีมีตถางอออตตุญนงอ | MENTS:<br>NODE PAIR<br>NODE PAIR<br>NOT PAIR<br>NOT NOT NOT PAIR<br>NOT NOT NOT NOT NOT NOT NOT NOT NOT NOT  |                                | REAL<br>-2.77042E-02<br>-3.77983E-02      |
| <b>៹៷ៜ៲៷៰៓ឣ៰៰៸៹៷៹</b> ៹៹៹៹៰៰៰៹៹ៜ៹៹៹៹៷                                  | 20 กา ASSIGN<br>PORT<br>NUTBER<br>เนาย<br>เนา<br>เนา<br>เนา<br>เนา<br>เนา<br>เนา<br>เนา<br>เนา<br>เนา<br>เนา | TRST ORDER                     | PC<br>XC<br>M<br>M<br>M<br>M              |

FREQUENCY( 2 )= 3.250E+06

FIRST ORDER:

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|             | PRASE<br>DEG | -143.87<br>-158.83           |               |              | FRASE<br>DEG | -131.65                      |               |             | FRASE<br>DEC | -125.40                      |              |             | 931<br>1369 | 150.00                                      |               |             | PKASE<br>DEG | -141.19                      |
|-------------|--------------|------------------------------|---------------|--------------|--------------|------------------------------|---------------|-------------|--------------|------------------------------|--------------|-------------|-------------|---------------------------------------------|---------------|-------------|--------------|------------------------------|
| AGE         | MAGNITUDE    | 3.699722-02<br>4.341685-02   |               | AGE          | MAGNITUDE    | 1.161555-03<br>2.410202-03   |               | AGS         | MAGNITUDE    | 2.497402-03<br>4.959941-03   |              | AGE         | MAGNITUDE   | 2.630765-13<br>2.630522-03                  |               | AGE         | MAGNI TUDE   | 1.33712E-03<br>2.56220E-03   |
| DUTPUT VOLT | IMAGINARY    | -1.91258E-02<br>-1.56788E-02 |               | autrur volti | IMAGINARY    | -8.67748E-04<br>-2.40986E-03 |               | OUTPUT VOLT | IMAGINARY    | -1.72220E-03<br>-4.557292-03 |              | OUTPUT VOLT | IMAGINARY   | 00                                          |               | DUTPUT VOLT | IMAGINARY    | -8.37965E-04<br>-2.54192E-03 |
|             | REAL         | -3.16702E-02<br>-4.04870E-02 |               |              | REAL         | -7.72160E-04<br>-4.00861E-05 |               |             | REAL         | -1.80850E-03<br>-3.54335E-04 |              |             | REAL        | -2.239765-13<br>-2.63862E-03                |               |             | REAL         | -1.04198E-03<br>-3.21771E-04 |
|             | ZOLOG MAG    | -2.72468E+01                 | IG H2         |              | ZOLOG MAG    | -5.25785E+01<br>-4.63384E+01 | IG HZ         |             | ZOLDG MAG    | -5.205025+01<br>-4.607302+01 | 0 HZ         |             | 20LDC MAG   | -2.52396E+02<br>-5.15723E+01                | IG HZ         |             | 20LOG MAG    | -5.14560E+01<br>-4.58071E+01 |
| FUNCTION    | MAGNI TUDE   | 3.69972E-02<br>4.34163E-02   | 1 )= 5.000E+0 | FUNCTION     | MAGNITUDE    | 2.32312E-03<br>4.82039E-03   | 2 )≈ 6.250E+0 | FUNCTION    | MAGNITUDE    | 2.49740E-03<br>4.93334E-03   | 1 )=         | FUNCTION    | MAGNITUDE   | 2.239766-13<br>2.63862E-03                  | 2)= 6.500E+0  | FUNCTION    | MAGNI TUDE   | 2.67425E-03<br>5.12441E-03   |
| TRANSFER    | IMAGINARY    | -1.91258E-02<br>-1.56788E-02 | FREQUENCY( 1, | TRANSFER     | IMAGINARY    | -1.73550E-03<br>-4.81972E-03 | FREQUENCY( 1, | TRANSFER    | IMAGINARY    | -1.722205-03<br>-4.95729E-03 | FREGUENCY( 1 | TRANSFER    | IMAGINARY   | 60                                          | FREQUENCY( 2. | TRANSFER    | Imaginary    | -1.67593E-03<br>-5.08384E-03 |
|             | REAL         | -3.16702E-02<br>-4.04370E-02 | 2:            |              | REAL         | -1.54432E-03<br>-8.01721E-05 | ÷             |             | REAL         | -1.805505-03<br>-3.543355-04 | ÷            |             | LEAL        | -2.239765-13<br>-2.539765-13<br>2.533625-03 |               |             | REAL         | -2.03355-03<br>-6.43542E-04  |
|             | PORT<br>NO   | ຒຓ                           | SECOND ORDER  |              | PORT<br>NO   | ຸດເຕ                         | SECOND ORDER  |             | PORT<br>NO   | ດເຕ                          | SECOND ORDER |             | PORT<br>NO  | ີ.ດາຕ                                       | SECOND ORDER  |             | PC2T<br>NO   | ณฑ                           |

OUTPUT VOLTAGE

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FREQUENCY( 2,-1 )= 2.500E+05

SECOND ORDER:

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TRANSFER FUNCTION

| PORT          | REAL                         | IMAGINARY                    | MAGNI TUDE                 | 20LOG MAG                    | REAL                         | IMAGINARY                    | MAGNITUDE                  | DEG                                                                                         |
|---------------|------------------------------|------------------------------|----------------------------|------------------------------|------------------------------|------------------------------|----------------------------|---------------------------------------------------------------------------------------------|
| ิณฑ           | 1.02843E-06<br>2.73984E-03   | -1.54661E-05<br>-1.55166E-04 | 1.55002E-05<br>2.74423E-03 | -9.61932E+01<br>-5.12316E+01 | 1.02843E-06<br>2.73984E-03   | -1.54661E-05<br>-1.55166E-04 | 1.55002E-05<br>2.74423E-03 | -85.20<br>-3.24                                                                             |
| SECOND DRDER: |                              | FREQUENCY( 2+-               | 2 )=                       | 0 HZ                         |                              |                              |                            |                                                                                             |
|               |                              | TRANSFER                     | FUNCTION                   |                              |                              | OUTPUT VOLTA                 | <b>GE</b>                  |                                                                                             |
| PORT<br>NO    | REAL                         | IMAGINARY                    | MAGNITUDE                  | ZOLOG MAG                    | REAL                         | IMAGINARY                    | MAGNITUDE                  | PHASE<br>DEG                                                                                |
| ຸດາຍ          | -2.15878E-13<br>-2.53205E-03 | 00                           | 2.15878E-13<br>2.63205E-03 | -2.53316E+02<br>-5.15941E+01 | -2.15878E-13<br>-2.63205E-03 | 00                           | 2.158785-13<br>2.632055-03 | 130.00                                                                                      |
| THIRD ORDER:  | •                            | FREQUENCY( 1, 1              | • 1 )= 9.000E              | +06 HZ                       |                              |                              |                            |                                                                                             |
|               |                              | TRANSFER                     | FUNCTION                   |                              |                              | OUTPUT VOLTA                 | JCE                        |                                                                                             |
| PORT          | REAL                         | IMAGINARY                    | MAGNI TUDE                 | SOLOG MAG                    | REAL                         | IMAGINARY                    | MAGNITUDE                  | PKASE<br>Dec                                                                                |
| ູດຕ           | -1.33034E-03<br>-1.51580E-03 | 3.61338E-04<br>-1.62911E-03  | 1.43652E-03<br>2.22523E-03 | -5.30525E+01                 | -3.47584E-04<br>-3.78950E-04 | 9.03344E-05<br>-4.07277E-04  | 3.591315-04<br>5.56307E-04 | 165.40<br>-122.94                                                                           |
| THIRD ORDER:  |                              | FREQUENCY( 1, 1              | , 2 )= 9.250E              | +00 HZ                       |                              |                              |                            |                                                                                             |
|               |                              | TRANSFER                     | FUNCTION                   |                              |                              | алгрит иагтр                 | 305                        |                                                                                             |
| PORT<br>NO    | REAL                         | IMAGINARY                    | MAGNITUDE                  | ZOLDG MAG                    | REAL                         | IMAGINARY                    | <b>MAGNI TUDE</b>          | PKASS<br>DEG                                                                                |
| ດຕ            | -1.38397E-03<br>-1.63825E-03 | 4.96255E-04<br>-1.53553E-03  | 1.47496E-03<br>2.27986E-03 | -5.28418E+01                 | -1.041735-03<br>-1.22869E-03 | 3.72191E-04<br>-1.189152-03  | 1.106225-03<br>1.705505-03 | 160.34<br>-133.94                                                                           |
| THIRD ORDER:  |                              | FREDUENCY( 1, 1              | •-1 )= 3.000E              | +0S HZ                       |                              |                              |                            |                                                                                             |
|               |                              | TRANSFER                     | FUNCTION                   |                              |                              | ουτΡυτ νοιτε                 | 506                        |                                                                                             |
| PORT<br>NO    | REAL                         | IMAGINARY                    | MAGNITUDE                  | 20LOG MAG                    | REAL                         | IMAGINARY                    | MAGNI TUBE                 | PHAGE<br>DEG                                                                                |
| លក            | 4.916865-05<br>6.51G91E-04   | -1.49523E-04<br>-1.78205E-04 | 1.57400E-04<br>9.40565E-04 | -7.60599E+01<br>-5.05322E+01 | 3.687655-05<br>4.88768E-04   | -1.12142E-04<br>-5.08654E-04 | 1.150505-04<br>7.054242-04 | -45.14                                                                                      |
| THIRD ORDER:  |                              | FREQUENCY( 1. 1              | 2)= 2.750E                 | :+0E HZ                      |                              |                              |                            |                                                                                             |
|               |                              | TRANSFER                     | FUNCTION                   |                              |                              | DUTPUT VOLTA                 | AGE                        |                                                                                             |
| PORT<br>NO    | REAL                         | IMAGINARY                    | MAGNITUDE                  | 20LDG MAG                    | REAL                         | Imaginary                    | HERITUDE                   | FKASI<br>Dig                                                                                |
| ิณฑ           | 4.832235-05<br>6.85304E-04   | -1.245305-04<br>-5.377395-04 | 1.33570E-04<br>9.37235E-04 | -7.74793E+01<br>-6.05630E+01 | 3.62421E-05<br>5.15103E-04   | -9.347235-05<br>-4.783045-04 | 1.002352-04<br>7.029327-04 | 1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1<br>1 |

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9.500E+06 FREQUENCY( 1. 2. 2 )=

THIRD DRDCR:

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|              |                              | TRANSFER                     | FUNCTION                   |                              |                              | DUTFUT UDLTG                 | 305                        |                  |
|--------------|------------------------------|------------------------------|----------------------------|------------------------------|------------------------------|------------------------------|----------------------------|------------------|
| 7004<br>707  | REAL                         | IMAGINARY                    | MAGNI TUDE                 | ZOLDG MAG                    | REAL                         | IMAGINARY                    | MAGNITUDE                  | PRASE<br>DEG     |
| 2 .          | -1.37264E-03<br>-1.75050E-03 | 6.31730E-04<br>-1.53393E-03  | 1.51103E-03<br>2.33501E-03 | -5.26342E+01<br>-5.26342E+01 | -1.02948E-03<br>-1.32037E-03 | 4,73797E-04<br>-1,15045E-03  | 1.75126E-03                | 155.29           |
| THIRD ORDER: |                              | FREQUENCY( 1, 2              | 1)= 3.250E                 | +05 HZ                       |                              |                              |                            |                  |
|              |                              | TRANSFER                     | FUNCTION                   |                              |                              | מעדפעד טמבדו                 | AGE                        |                  |
| PORT<br>NO   | REAL                         | i mag i nazy                 | MAGNITUDE                  | ZOLOG MAG                    | REAL                         | IMAGINARY                    | MAGNITUDE                  | PKASS<br>DEG     |
| N M          | 4.59982E-05<br>6.35931E-04   | -7.373355-04                 | 1.84861E-04<br>9.74215E-04 | -7.46631E+01<br>-6.02269E+01 | 7.04972E-05<br>9.53972E-04   | -2.62181E-04<br>-1.10698E-03 | 2.772525-04<br>1.451325-03 | -75.27<br>-49.25 |
| THIRD CRDER: |                              | FREQUENCY( 1, 2              | 1-2)= 3.000E               | :+0E HZ                      |                              |                              |                            |                  |
|              |                              | TRANSFER                     | FUNCTION                   |                              |                              | מעדפעד עמרדו                 | AGS                        |                  |
| PORT<br>NÜ   | REAL                         | IMAGINARY                    | MAGNITUDE                  | ZOLDG MAG                    | REAL                         | IMAGINARY                    | MAGNITUDE                  | PHASE<br>DEC     |
| n n          | 4.52723E-05                  | -1.46950E-04<br>-6.79441F-04 | 1.54675E-04<br>9.44822E-04 | -7,62116E+01<br>-6,04930E+01 | 7.24094E-05<br>9.84815E-04   | -2.20424E-04                 | 2.220135-04<br>1.417235-03 | -71.81           |

1.91475E-04 3.85200E-04 -3.68555E-04 5.97655E-04 DUTPUT VOLTAGE OUTPUT UDLTAGE IMAGINARY IMAGINARY -3.35392E-04 -4.70526E-04 REAL REAL 4.22729E-05 -1.46950E-04 1.54675E-04 -7.62116E+01 6.56543E-04 -6.79441E-04 9.44822E-04 -6.04930E+01 7.659016-04 1.54480E-03 -5.6225E+01 -1.47422E-03 2.39074E-03 -5.24294E+01 ZOLOG MAG 20LDG MAG FREQUENCY( 2, 2,-1 )= 3.500E+05 HZ ¥ FREQUENCY( 2, 2, 2 )= 3.750E+06 Imrginary magnitude MAGNI TUDE TRANSFER FUNCTION TRANSFER FUNCTION IMAGINARY -1.341575-03 -1.882105-03 REAL REAL THIRD ORDER: THIRD ORDER: POR SOL POR 20 20 20 20 20 20

150.23

PKASS

MAGNI TUBE

-2.20424E-04 -1.01916E-03

7.24094E-05 9.84815E-04

-78.95

-1.580386-04 1.610835-04 -5.994655-04 7.572775-04

3.08662E-05 4.62720E-04

4.11550E-05 -2.10797E-04 2.14777E-04 -7.33602E+01 6.16560E-04 -7.93237E-04 1.00370E-03 -5.99161E+01

FREQUENCY( 2. 2.-2 )= 3.250E+05 HZ

THIRD ORDER:

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TRANSFER FUNCTION

OUTPUT VOLTAGE

PKAST DEG

MAGNITUDE

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| PHASE<br>DEG |                                                                                                                   |  |
|--------------|-------------------------------------------------------------------------------------------------------------------|--|
| MAGNITUDE    |                                                                                                                   |  |
| IMAGINARY    |                                                                                                                   |  |
| REAL         | 2.4<br>2.42<br>2.42<br>2.42<br>2.42<br>2.42<br>2.42<br>2.42                                                       |  |
| 20LOG MAG    |                                                                                                                   |  |
| MAGNITUBE    | 1.755098-04<br>5.5317998-04<br>-04                                                                                |  |
| ABONI DONI   | -1.708302-04<br>-7.200355-04<br>-04                                                                               |  |
| REAL         | 6.55150<br>2.25150<br>9<br>9<br>9<br>0<br>4<br>0<br>4<br>0<br>4<br>0<br>4<br>0<br>4<br>0<br>4<br>0<br>4<br>0<br>4 |  |
| PORT         |                                                                                                                   |  |

INPUT FREQUENCIES: FREQUENCY URLUE( HZ)

1 2.3005+07

2 2.2255+07

FTRST GRDER: FREGUENCY( 1 )= 2.300E+07

TRANSFER FUNCTION

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OUTPUT VOLTAGE

|                | REAL                        | IMAGINARY                    | MAGNITUDE                  | SOLDG MAG                    | REAL                         | IMAGINARY                    | MAGNITUDS                  | PRASE                  |
|----------------|-----------------------------|------------------------------|----------------------------|------------------------------|------------------------------|------------------------------|----------------------------|------------------------|
|                | 2.719755-01<br>2.719755-01  | 1.200315-01<br>9.289405-01   | 3.90330E-01<br>1.29331E+00 | -3.15913E+00<br>2.23743E+00  | 3.71975E-01<br>-9.00568E-01  | 1.20091E-01<br>9.28940E-01   | 3.508305-01<br>1.293315+00 | DEG<br>17.89<br>134.11 |
| נא <u>:</u> ני |                             | FREQUENCY( 2 )=              | 2.3255+07                  | ZH                           |                              |                              |                            |                        |
|                |                             | TRANSFER                     | FUNCTION                   |                              |                              | 017PUT V0LT                  | AGE                        |                        |
|                | LREAL                       | TMAGINARY I                  | MAGNI TUDE                 | 20LOG MAG                    | REAL                         | IMAGINARY                    | MAGNI TUDE                 | PKASE<br>DEC           |
|                | 4.005355-01<br>-9.221642-01 | 1.049355-01<br>1.044722403   | 4.14155E-01<br>1.39343E+00 | -7.6565222400<br>2.832095+00 | 4.005365-01<br>-9.22164E-01  | 1.045935-01<br>1.044725+00   | 4.141655-01<br>1.352455-00 | 14 <b>59</b><br>131 43 |
| CRD52:         |                             | FREDUENCY( 1. 1              | 1 )= 4.600E+(              | 07 HZ                        |                              |                              |                            |                        |
|                |                             | TRANSFER                     | FUNCTION                   |                              |                              | 0UTPUT V0LT                  | AGE                        |                        |
|                | LREAL                       | <b>VARNI DEMI</b>            | MAGNITUDE                  | 20LOG MAG                    | REAL                         | IMAGINARY                    | EGNIINDEW                  | PKAST<br>DEG           |
|                | -1.017675-03<br>6.252855-02 | -2.593561-02<br>-5.817455-02 | 2.501575-02<br>3.56331E-02 | -3.16553E+01<br>-2.13405E+01 | -5.083355-04<br>3.146455-02  | -1.299795-02<br>-2.908735-02 | 1.300755-02<br>4.284SS5-02 | 92.26-<br>- 42.75      |
| ORD5R:         |                             | FREDUENCYC 1. 3              | 2 )= 4.525E+1              | 27 HZ                        |                              |                              |                            |                        |
|                |                             | TRANSFER                     | FUNCTION                   |                              |                              | OUTPUT VOLT                  | AGE                        |                        |
|                | REAL                        | IMAGINARY                    | MAGNI TUDE                 | ZOLOG MAG                    | REAL                         | IMAGINARY                    | INGNI TUDE                 | FKASE<br>DEG           |
|                | -2.201225-03<br>5.21337E-02 | -2.776335-02<br>-5.350625-02 | 2.785345-02<br>8.35483E-02 | -3.11024E+01<br>-2.09588E+01 | -2.201235-03<br>-2.31337E-02 | -2.776635-02<br>-6.350625-02 | 2.785341-02<br>2.554531-02 | -54.53<br>-43.17       |

-1.11713E-14 0 1.11713E-14 180.00

-1.11713E-14 -2.79038E+02

South Street

PHASE DEC

MAGNITUDE

IMAGINARY

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TRANSFER FUNCTION

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FREQUENCY( 1,-1 )=

SECOND ORDER:

OUTPUT VOLTAGE

OUTPUT VOLTAGE

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TRANSFER FUNCTION

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|                | I TUDE PHASE<br>DEG | 030E-02 -96.85<br>358E-02 -47.59            |                |                | I TUDE PHASE<br>DEG | 2425-05 -65.00<br>804E-02 -2.45          |              |                | ITUDE PHASE<br>DEG | 8552-14 180.00<br>037E-02 0  |                 |                | ITUDE PHASS<br>DEC | 0355-02 138.39<br>3185-03 -160.74      |                 |                | ITUDE PHASE<br>DEG | 4155-02 135.43   |
|----------------|---------------------|---------------------------------------------|----------------|----------------|---------------------|------------------------------------------|--------------|----------------|--------------------|------------------------------|-----------------|----------------|--------------------|----------------------------------------|-----------------|----------------|--------------------|------------------|
| UUTHUT UULTHUE | IMAGINARY MAGNI     | -1.480266-02 1.490<br>-3.455336-02 4.675    |                | OUTPUT VOLTAGE | IMAGINARY MAGNI     | -2.97124E-05 3.255<br>-3.48884E-03 8.128 |              | OUTPUT VOLTAGE | IMAGINARY MAGNI    | 0 1.055<br>0 8.660           |                 | autrut valtage | IMAGINARY MAGNI    | 7.63995E-03 1.156<br>-3.25366E-03 9.86 |                 | OUTPUT VOLTAGE | IMAGINARY MAGN     | 2.585265-02 3.68 |
|                | REAL                | -1.77793E-03<br>-1.77793E-03<br>3.15595E-02 |                |                | REAL                | 1.322865-05<br>8.12055E-02               |              | ·              | REAL               | -1.05899£-14<br>8.66037E-02  |                 |                | REAL               | -8.600655-03<br>-9.31107E-03           |                 |                | REAL               | -2.624765-02     |
|                | ZOLOG MAG           | -2.05751E+01                                | 5 HZ           |                | ZOLOG MAG           | -2.18003E+01                             | 0 HZ         |                | ZOLOG MAG          | -2.79502E+02<br>-2.12493E+01 | E+07 HZ         |                | ZOLOG MAG          | -2.674195+01<br>-2.80785E+01           | 2+07 HZ         |                | 20105 MAG          | -2.61745E+01     |
| EUNCTION       | MAGNITUDE           | 2.98179E-02<br>9.35935E-02                  | -1 )= 2.500E+C | EUNCTION       | MAGNITUDE           | 3.25242E-05<br>8.12804E-02               | 년 )=         | EUNCTION       | MAGNI TUDE         | 1.05839E-14<br>8.66037E-02   | 1, 1 )= S.900E  | R FUNCTION     | MAGNITUDE          | 4.60157E-02<br>3.94527E-02             | 1, 2)= 5.925E   | R FUNCTION     | MAGNI TUDE         | 4.912205-02      |
| TRANSFER       | Imaginary           | -2.93051E-02<br>-6.91066E-02                | FREDUENCY( 2   | TRANSFER       | IMAGINARY           | -2.97124E-05<br>-3.48884E-03             | FREQUENCY( 2 | TRANSFER       | IMAGINARY          | 0                            | FREQUENCY( 1, 1 | TRANSFER       | IMAGINARY          | 3.055325-02                            | FREQUENCY( 1. 1 | TRANSFER       | IMAGINARY          | 3.447025-02      |
|                | REAL                | -3.55585E-03<br>6.31191E-02                 |                |                | REAL .              | 1.32285E-05<br>B.12055E-02               |              |                | REAL               | -1.05899E-14<br>E.66037E-02  |                 |                | REAL               | -3.440255-02<br>-3.724435-02           |                 |                | REAL               | -3.423232-03     |
|                | PORT<br>NO          | ຒຕ                                          | SECOND ORDER   |                | PORT<br>NO          | លក                                       | SECOND ORDER |                | PORT<br>NO         | ເດຕ                          | THIRD ORDER:    |                | PORT               | ເທຍ                                    | THIRD ORDER:    |                | P0.81              | ດ                |

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7.62512E-02

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7.62512E-02 -2.23551E+01 7.62512E-02

FREGUENCY( 2, 2)= 4.650E+07 HZ

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7.62512E-02

3 Second Order:

| PHAST<br>DEC | 93.24<br>-137.05             |                 |             | PHASE<br>DEG | -132.12                                      |                 |             | PUASE<br>DEC | -100.40                      |                 |             | PRASE<br>DEG | -142.50                      |                 |             | PKAST<br>Dec | -137.00                      |                 |             | F14ASE<br>DEC | •                                                                                           |
|--------------|------------------------------|-----------------|-------------|--------------|----------------------------------------------|-----------------|-------------|--------------|------------------------------|-----------------|-------------|--------------|------------------------------|-----------------|-------------|--------------|------------------------------|-----------------|-------------|---------------|---------------------------------------------------------------------------------------------|
| MAGNITUDE    | 1.34742E-01<br>4.35264E-01   |                 | AGE         | MAGNITUDE    | 1.365295-01<br>4.375165-01                   |                 | AGE         | HORI TUDE    | 3. 532555-02<br>3. 327502-02 |                 | AGE         | MAGNITUDE    | 3.056051-01<br>9.855582-01   |                 | AGE         | MAGNITUDE    | 3.050742-01<br>9.887315-01   |                 | AGE         | MAGNI TUDE    |                                                                                             |
| IMAGINARY    | 1.33350E-01<br>-2.96510E-01  |                 | OUTPUT VOLT | IMAGINARY    | -3.24504E-01                                 |                 | оитрит Volt | IMAGINARY    | 2.90002E-02<br>-7.82587E-03  |                 | ουτΡυτ νοιτ | IMAGINARY    | 3.02192E-01<br>-6.02346E-01  |                 | OUTPUT VOLT | IMAGINARY    | 3.02922E-01<br>-6.73360E-01  |                 | αυτΡυτ ναιτ | Imaginary     | ·<br>·<br>·<br>·<br>·<br>·                                                                  |
| REAL         | -1.93202E-02<br>-3.18648E-01 |                 |             | REAL         | -2.11883E-02<br>-2.93458E-01                 |                 |             | REAL         | -2.65614E-02<br>-3.23458E-02 |                 |             | REAL         | -1.57471E-02<br>-7.80067E-01 |                 |             | REAL         | -4.38090E-02<br>-7.24000E-01 |                 |             | REAL          |                                                                                             |
| 20LOG MAG    | -1.49112E+01<br>-4.72617E+00 | ZH 20+:         |             | 20LOC MAG    | -1.47967E+01<br>-4.68134E+00                 | ZH 20+          |             | SOLOG MAG    | -2.56077E+01<br>-2.70578E+01 | ZH ∠0+          |             | 20LOG MAG    | -1.33044E+01<br>-3.64318E+00 | ZH 20+          |             | ZOLDC MAC    | -1.38053E+01<br>-3.62026E+00 | ZH 20+.         |             | SOLOG MAG     | •                                                                                           |
| MAGNITUDE    | 1.79656E-01<br>5.80352E-01   | •-2)= 2.275E    | FUNCTION    | MAGNITUDE    | 1.82039E-01<br>5.83355E-01                   | , 2 )= 6.950E   | FUNCTION    | MAGNI TUDE   | 5.24344E-02<br>4.43720E-02   | 1 )= 2.325E     | FUNCTION    | MAGNITUDE    | 2.01734E-01<br>6.57033E-01   | •-2)= 2.300E    | FUNCTION    | MAGNI TUDE   | 2.04043E-01<br>6.59154E-01   | , 2 )= 6.975E   | FUNCTION    | MAGNI TUDE    | •<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>•<br>• |
| IMAGINARY    | 1.77800E-01<br>-3.95346E-01  | FREQUENCY( 1. 1 | TRANSFER    | IMAGINARY    | 1.77226E-01<br>-4.32673E-01                  | FREQUENCY( 1. 2 | TRANSFER    | IMAGINARY    | 3.866595-02<br>-1.043455-02  | FREQUENCY( 1. 2 | TRANSFER    | IMAGINARY    | 2.01451E-01<br>-4.01564E-01  | FREQUENCYC 1. 2 | TRANSFER    | IMAGINARY    | 2.013482-01<br>-4.439072-01  | FREQUENCY( 2, 2 | TRANSFER    | IMAGINARY     |                                                                                             |
| REAL         | -2.57602E-02<br>-4.24864E-01 |                 |             | REAL         | -4.15843E-02<br>-4.15843E-02<br>-3.91277E-01 |                 |             | REAL         | -3.54152E-02<br>-4.31277E-02 |                 |             | REAL         | -1.04931E-02<br>-5.20045E-01 |                 |             | REAL         | -2.320505-02<br>-4.32667E-01 |                 |             | REAL          |                                                                                             |
| PORT<br>NO   | ຸດເຕ                         | THIRD ORDER:    |             | PORT<br>NO   | ຸດເຕ                                         | THIRD ORDER:    |             | PORT         | លក                           | THIRD ORDER:    |             | 7087<br>NO   | ຸດເຕ                         | THIRD ORDER:    |             | РО?Т<br>NO   | ຸດເຕ                         | THIRD CRDER:    |             | PCRT<br>NO    | •<br>•<br>•                                                                                 |

53 97 142 34 37.39 -147.93 123.54 -169.23 PKAGE DEG PHASE DEG 1.39917E-02 1.17647E-02 7.746495-03 1.699505-01 1.701275-01 -4.73595E-01 -2.55506E-01 5.58757E-01 1.716005-01 1.718315-01 -3.419582-01 5.59654E-01 MAGNI-UDE MAGNITUDE OUTPUT VOLTAGE OUTPUT VOLTAGE 1.07893E-02 -2.19884E-03 IMAGINARY IMAGINARY -8.90679E-03 -4.43032E-01 -8.90781E-03 -1.15574E-02 REAL REAL 2.28201E-01 2.29109E-01 -1.27992E+01 -4.55944E-01 7.45203E-01 -2.54283E+00 2.26600E-01 2.26833E-01 -1.28858E+01 -3.95342E-01 7.45003E-01 -2.55677E+00 -2.50414E+01 -2.65472E+01 ZOLOG MAG ZOLOG MAG ¥ FREQUENCY( 2, 2,-1 )= 2.350E+07 HZ FREQUENCY( 2, 2,-2 )= 2,325E+07 5.53669E-02 4.70589E-02 MAGNITUDE MAGNI TUDE TRANSFER FUNCTION TRANSFER FUNCTION 4.31591E-02 -8.79537E-03 IMAGINARY IMAGINARY -1.13757E-02 -5.90709E-01 1.03286E-02 -6.31461E-01 -3.56312E-02 -4.62296E-02 REAL REAL THIRD ORDER: THIRD ORDER: NO SOUTION SOU PORT NO NO NO NO იკი

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| 4.2535+07<br>FREDUENCYC J<br>TRAN | FREGUENCYC       | 1 )≈<br>5FE/3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 4.300E+07<br>Fumintini     | Ŷ                            |                                             | ITION INGTIO                                | ۵<br>تان                   |                                                                    |
|-----------------------------------|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|------------------------------|---------------------------------------------|---------------------------------------------|----------------------------|--------------------------------------------------------------------|
|                                   |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1011201                    |                              |                                             | ממודטו עטבא                                 | HGL                        |                                                                    |
| ಗತು.                              |                  | IMAGINARY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | MAGNI TUDE                 | 20LDG MAG                    | REAL                                        | IMAGINARY                                   | MAGNITUDE                  | 1000<br>1000<br>1001<br>1001<br>1001<br>1001<br>1001<br>100        |
| 4.00005                           | 20-37            | -3.039142-02<br>-3.975582-02                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 5.707415-02<br>5.192845-01 | -2.437126+01<br>-5.591905+00 | -4.820535-02<br>-4.820535-02<br>5.177605-01 | -3.059145-02<br>-2.875685-02                | 5.207412-02<br>5.222342-01 | -147.83                                                            |
|                                   |                  | F7E0U5NC/( 2 )=                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 4.3255+07                  | HZ                           |                                             |                                             |                            |                                                                    |
|                                   |                  | TRANSFER                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | FUNCTION                   |                              |                                             | 0UTPUT V0LT1                                | USE                        |                                                                    |
| UEU                               | - 1              | 149CIISSNE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | ECT TOPE                   | 20105 MAS                    | LER_                                        | IMAGINATY                                   | <b>TUDEN</b>               | (0)<br>(0)<br>(0)<br>(0)<br>(0)<br>(0)<br>(0)<br>(0)<br>(0)<br>(0) |
| 4, 7635<br>8, 1490                | 10-11<br>11-02   | -4.041585-02                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 5.510355-02<br>5.156245-01 | -2.501932001<br>-5.752503000 | -4.765505-02<br>5.140372-01                 | -2.569235-02<br>-4.041583-02                | 5.6:0522-02<br>5.6:0522-02 |                                                                    |
|                                   |                  | F .I A CHENDELY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | I)≈ 3.5005+(               | 24 H2                        |                                             |                                             |                            |                                                                    |
|                                   |                  | 12416421                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | FUNCTION                   |                              |                                             | ουτρυτ νοιτκ                                | AGE                        |                                                                    |
| 6)<br>C.                          | 2                | 172813213271                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | MAGNETUDE                  | ZOLOG MAG                    | 1995<br>1995                                | A 2 UNICONDI                                | EGALINDAN                  | E OFFE                                                             |
| 56                                | 00-301<br>105-00 | -4.103372-04<br>1.723052-04                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 1.533482-03<br>1.493105-03 | -5.625255+01<br>-5.631772+01 | 7.407005-04<br>7.415745-04                  | -2,024445-04<br>-2,024445-04<br>8.641755-05 | 7.697495-04<br>7.405835-04 |                                                                    |
|                                   |                  | FPEQUENCIA 24                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 2)= 3.5255+(               | ZH 20                        |                                             |                                             |                            |                                                                    |
|                                   |                  | STRATES TO S | FUNCTION                   |                              |                                             | 0UTPUT VOLT/                                | BGE                        |                                                                    |
| LU<br>L                           | , i<br>C         | 1.8942504.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | insen tube                 | 20102 440                    | PERL                                        | <b>VARATIONI</b>                            | MAGNETUDE                  | FRAST<br>DEC                                                       |
|                                   | 015-03<br>202-03 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1.513355-03<br>1.431435-03 | -5.633342+01<br>-5.63276E+01 | 1.451015-03<br>1.453285-03                  | -4.191325-04<br>1.563372-04                 | 1.515521+03<br>1.491452+03 | -15-01<br>5-02                                                     |
|                                   |                  | FPEQUE1107( 11                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | ۲ ]۲                       | 0 HZ                         |                                             |                                             |                            |                                                                    |
|                                   |                  | TPAKSFER                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | FUNCTION                   |                              |                                             | מטדפעד טמיבוא                               | ACE                        |                                                                    |
| G.                                | . 1<br>CT        | Lag Digar                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 300111068                  | 20LOG MAG                    | LEAL                                        | IMAGINARY                                   | TIAGNETUDE                 | PRASE<br>Dig                                                       |
| 2,537(                            | 155-15           | Ű                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 2.667055-15                | -2.91479E+02                 | -2.657055-15                                | 0                                           | 2.EG7032-15                | 139.69                                                             |

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INPUT FREQUENCIES: FREQUENCY UNLUE( HZ)

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999 999 999 ំព ខ្លួំ ខ្លួំ -64-00-00.00 23.52 53.53 0 PHASE DEG PNASS DEG FUACE DEG PEAST DEG 7.503205-04 7.450752-04 3.801405-04 1.265555-04 1.232455-04 4.631232-03 3.545585-03 1.503765-03 3.502345-03 MAGNITUDE MAGNITUDS MAGNITUDE REGNITUDE MAGNITUDE OUTPUT VOLTAGE OUTPUT VOLTAGE DUTPUT VOLTAGE OUTPUT VOLTAGE OUTPUT VOLTAGE 2.557805-04 1.203495-04 8.675052-05 4.062302-05 -1.352545-05 1.11219E-05 -2.005965-04 7.00045E-05 0 00 -2.623145-15 3.455995-03 IMAGINARY IMAGINARY IMAGINARY IMAGINARY IMAGINARY 2.81217E-04 -6.53807E-05 7.20433E-04 7.41783E-04 6.572495~07 3.502325-03 9.45871E-05 -2.22415E-05 3.54558E~03 REAL REAL REAL REAL REAL -4.90063E+01 -2.623145-15 0 2.523145-15 -2.916345+02 3.455995-03 0 3.455995-03 -4.322855+01 3.47002E-04 5.13372E-04 -6.57912E+01 1.62432E-04 1.83253E-04 -7.46447E+01 -1.16456E+02 -4.91128E+01 3.410405-04 5.05334E-04 -6.59023E+01 1.604655-04 1.82616E-04 -7.47692E+01 1.5005EE-03 -5.64744E+01 1.49015E-03 -5.65354E+01 ZOLOG MAG 20LOG MAG ZOLOG MAG ZOLDG MAG 20LOC MAG FREQUENCY( 1, 1, 1) = 1.290E+08 HZ FREQUENCY( 1, 1, 2 )= 1.293E+08 HZ FREQUENCY( 2, 2)= 8.650E+07 HZ 2.500E+05 HZ 0 HZ 3.54558E-03 -1.35254E-05 1.50378E-06 1.11215E-05 3.50234E-03 MAGNI TUDE MAGNI TUDE MAGNI TUDE MAGNITUDE MAGNI TUDE TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION FREQUENCY( 2,~1 )= FREDUENCY( 2, ~2 )= -4.19392E-04 1.40009E-04 IMAGINARY IMAGINARY 0 IMAGINARY IMAGINARY IMAGINARY 3.78343E-04 -8.85353E-05 3.749555-04 -3.717435-05 1.44037E-03 1.48357E-03 6.572495-07 3.502325-03 3.54558E-03 REAL REAL REAL REAL REAL SECOND ORDER: SECOND ORDER: SECOND ORDER: THIRD ORDER: THIRD ORDER: ND ND ND ND ND ໙ო PORT DD ุ่ณต PORT NO POR T ຎຕ ຕມ m

OUTPUT VOLTAGE

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FREQUENCY( 1, 1,-1 )= 4.300E+07

THIRD ORDER:

TRANSFER FUNCTION

-111 60 -511.23 42.03 110.73 -110.74 CS 0371 P://655 DEC 5555 1535 1535 PEAGE DEG FNAGE DEG PRASE DEG 2.951532-04 7.815733-04 2.911052-04 7.83291E-04 -5.45891E-04 5.837242-04 -1.10911E-03 1.521632-03 5.75283E-04 1.52363E-04 2.513765-04 3.752025-04 1.188495-04 1.350182-04 MAGNITUDE MAGNITUDE MAGNITUDE MAGNITUDE MAGNITUDE RAGNITUDE OUTPUT VOLTAGE DUTPUT VOLTAGE OUTPUT VOLTAGE OUTPUT VOLTAGE OUTPUT VOLTAGE -2.755545-04 -5.68331E-04 -2.71297E-04 -5.67857E-04 -2.06053E-04 -5.37229E-04 1.04521E-03 -1.10765E-03 IMAGINARY IMAGINARY IMAGINARY IMAGINARY IMACINARY IMAGINARY -1.057598-04 5.365226-04 ............ -1.05550E-04 5.39520E-04 2.785285-04 -6.406288-05 -2.05754E-04 1.04207E-03 REAL REAL REAL REAL REAL REAL -3.674055-04 3.93537E-04 -6.81003E+01 -7.57775E-04 1.04210E-03 -5.96418E+01 -3.61729E-04 3.83141E-04 -6.82202E+01 -7.57143E-04 1.04439E-03 -5.96228E+01 3.71582E-04 3.35162E-04 5.00411E-04 -6.501355+01 -8.54171E-05 1.58456E-04 1.5002:E-04 -7.48936E+01 -3.53321E-04 3.59143E-04 -6.81977£+01 -3.53321E-04 3.59143E-04 -6.81977£+01 -7.39409E-04 1.01457E-03 -5.98744E+01 -3.58153E-04 3.83593E-04 -6.83226E4+01 -7.38434E-04 1.01575E-03 -5.98642E+01 20LOC MAG 20LOC MAG 20LOG MAC ZOLOC MAC 20LOG MAG 20LOG MAG FREQUENCY( 1, 1,-2 )= 4.275E+07 HZ FREQUENCY( 1, 2, 2 )= 1.295E+08 HZ HZ H FREQUENCY( 2, 2, 2)= 1.298E+08 HZ FREQUENCY( 1. 2.-2)= 4.300E+07 FREQUENCY( 1, 2,-1 )= 4.325E+07 MAGNI TUDE MAGNITUDE MAGNI TUDE MAGNITUDE MAGNI TUDE MAGNI TUDE TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION IMAGINARY IMAGINARY IMAGINARY IMAGINARY IMAGINARY IMAGINARY -1.41012E-04 7.15363E-04 -1.40734E-04 7.19361E-04 -1.378365-04 6.947125-04 -1.37368E-04 6.37472E-04 REAL REAL REAL REAL REAL REAL THIRD ORDER: THIRD ORDER: THIRD ORDER: THIRD CRDER: THIRD ORDER: PC:R1 2027 ູດເຕ PORT DN ດາພ PORT NO ຸດເຕ 7021 707 ເທຍ PCRT NO PORT NO . . . . . . ....

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| 41.51                        |                                    |              | PXASE<br>556        | -10.51                                      |                             | E<br>S<br>S<br>S<br>S<br>S<br>S<br>S<br>S<br>S<br>S<br>S<br>S<br>S<br>S<br>S<br>S<br>S<br>S<br>S |                                      |
|------------------------------|------------------------------------|--------------|---------------------|---------------------------------------------|-----------------------------|--------------------------------------------------------------------------------------------------|--------------------------------------|
| 1.235123-04<br>4.436653-03   |                                    | 336          | MAGNITUDE           | 20-302328                                   | 359                         | Regneture                                                                                        | 2.842841-04<br>7.410655-04           |
| 8.234622-05<br>3.912292-05   |                                    | 017PUT V0171 | IMAGINARY           | -2.703505-04<br>-5.412105-04                | סטדפטו עסיין                | <b>ARALIDARI</b>                                                                                 | -2.655501-04<br>-5.402285-04         |
| 9.205635-05<br>-2.052342-05  |                                    |              | LEAL                | -1.011265-04<br>5.061035-04                 |                             | 1450                                                                                             | -1.005403-04<br>5.072035-04          |
| -6.612465+01<br>-7.50177E+01 | FREQUENCY( 2, 2,-1 )= 4.330E+07 HZ |              | REGNITURE ZOLOG MAG | -5.010515+01<br>-6.010515+01                | -+07 HZ                     | 20105 MAS                                                                                        | -5.242378+01<br>-5.010412+01         |
| 4.940495-04<br>1.774635-04   |                                    | FUNCTION     |                     | 3.345535-04<br>9.373755-04                  | 2 )= 4.325E<br>FUNCTION     | HAGHTTUBE                                                                                        | 3. 731525-04<br>3. 330335-04         |
| 3.233355-04<br>1.534322-04   |                                    | TRANSFER     | IMAGINARY           | -3.604575-04                                | FREDUENCY( 2, 2<br>TRANSFER | LIASENARY                                                                                        | -3.545155-04<br>-7.292015-04         |
| 3.622255-04<br>+3.03335-04   |                                    |              | LIEAL               | -1.243352-04<br>-1.243352-04<br>6.743105-04 |                             | TUEU                                                                                             | -1.01074-04<br>6.700776-04           |
| លព                           | HIRD ORDER:                        |              | PORT                | 2                                           | אבמאם פאוא:                 | PORT                                                                                             | 9<br>9<br>9<br>9<br>9<br>9<br>9<br>9 |

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| ດາ           | G.3255+07                   |                              |                            |                              |                              |                              |                             |                      |
|--------------|-----------------------------|------------------------------|----------------------------|------------------------------|------------------------------|------------------------------|-----------------------------|----------------------|
| FIRST ORDER: |                             | FREQUENCY( 1 )=              | 6.300£+07                  | HZ                           |                              |                              |                             |                      |
|              |                             | TRANSFER                     | FUNCTION                   |                              |                              | מעדפעד עמיבד                 | .AG5                        |                      |
| PORT<br>NO   | LAEA'                       | IMAGINARY                    | MAGNITUDE                  | 20LOG MAG                    | REAL                         | IMAGINARY                    | TUDE                        | PRASE<br>DEC         |
| ດເຕ          | -2.050555-02<br>3.821625-01 | -6.533725-03<br>-6.535225-03 | 2.119835-02<br>3.37711E-01 | -3.347405+01<br>-3.22984E+00 | -2.050595-02<br>3.821525-01  | -5.373735-03<br>-6.53621E-02 | 2.115325-02<br>3.877115-00  |                      |
| FIRST ORDER: |                             | FREGUENCY( 2)=               | 6.325E+07                  | ΣH                           |                              |                              |                             |                      |
|              |                             | TRANSFER                     | FUNCTION                   |                              |                              | 0UTPUT V0LT                  | ISS .                       |                      |
| F021<br>50   | LREAL                       | IMAGINARY                    | MAGNI TUDE                 | SOLOG MAG                    | REAL                         | IMAGINARY                    | MAGNITUEE                   | 1971<br>1971<br>1971 |
| ຸດເຕ         | -2.035335-02<br>3.815955-01 | -5.301372-02                 | 2.103755-02<br>3.855325-01 | -3.353995+01<br>-3.245955+00 | -2.025595-02<br>-2.815955-01 | -5.201805-03<br>-6.557435-02 | 2.102752-01<br>2.85552-01   | 02.20.<br>62.120<br> |
| SECOND CLDEF |                             | FREQUENCYC 1. 1              | 1 )= 1.2505+               | 03 HZ                        |                              |                              |                             |                      |
|              |                             | TRANSFER                     | FUNCTION                   |                              |                              | דיטט דטקדנס                  | EDU                         |                      |
| PORT<br>NO   | LREAL                       | IMAGINARY                    | MAGNITUDE                  | 20105 MAC                    | REAL                         | IMAGENARY                    | RAGNITURE                   | 650<br>150<br>1      |
| ເດເບາ        | 2.857035-04<br>1.41430E-03  | -2.555795-04<br>-1.018255-03 | 3.900755-04<br>1.74313E-03 | -5.51734E+01                 | 1.42851E-04<br>7.07402E-04   | -1.327895-04<br>-5.091255-04 | 1.950375-04<br>8.715555-04  |                      |
| SECOND ORDER |                             | FREDUENCY( 1, 2              | e )= 1.2635+               | 08 HZ                        |                              |                              |                             |                      |
|              |                             | TRANSFER                     | FUNCTION                   |                              |                              | αυτρυτ νοιτ                  | ษธร                         |                      |
| РОХТ<br>110  | PEA'                        | Imaginary                    | MAGNITUDE                  | ZOLOG MAG                    | FEAL                         | IMAGENARY                    | TRENITUDE                   | PECCE<br>DEC         |
| ณฑ           | 2.83331E-04<br>1.41321E-03  | -2.545745-04<br>-1.022005-03 | 3.37722E-04<br>1.74403E-03 | -5.51689E+01                 | 2.83331E-04<br>1.41321E-03   | -2.645745-04<br>-1.022005-03 | 3.8772222-04<br>1.744052-03 | -43, 65<br>-05, 01   |
| SECOND ORDER | :2                          | FREDUENCY( 11                | 1 )=                       | 0 HZ                         |                              |                              |                             |                      |
|              |                             | TRANSFER                     | FUNCTION                   |                              |                              | αυτρυτ ναιτι                 | AGE                         |                      |
| PCRT<br>MD   | REAL                        | IMAGINARY                    | MAGNI TUDE                 | 20LOG MAG                    | REAL                         | IMAGINARY                    | <b>IDUTINDAN</b>            | FXASE<br>DEG         |
| ານ           | -8.31112E-16                | 0                            | 8.31112E-16                | -3.01607E+02                 | -8.31112E-16                 | 0                            | 8.311165-15                 | 159.00               |

INPUT FREQUENCIES: FREQUENCY VALUE( HZ)

REQUENCY URLUE ( H2) 1 G.3005+07

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9.13124E-04

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9.13124E-04

9.13124E-04 -6.07894E+01

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9.13124E-04

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SECOND ORDER:

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FREQUENCY( 2, 2 )= 1.265E+08 HZ

TRANSFER FUNCTION

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OUTPUT VOLTAGE

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PHASS DEG

1.92692E-04 8.72466E-04 MAGNITUDE OUTPUT VOLTAGE -1.31884E-04 -5.12871E-04 IMAGINARY 1.40487E-04 7.05805E-04 REAL -2.63768E-04 3.85383E-04 -6.82821E+01 -1.02574E-03 1.74493E-03 -5.51644E+01 ZOLDG MAG FREQUENCY( 2,-1 )= 2.500E+05 HZ MAGNITUDE TRANSFER FUNCTION IMAGINARY 2.80975E-04 1.41161E-03 REAL SECOND ORDER:

3.340655-07 9.082805-04 -3.33644E-07 5.12523E-06 1.68576E-08 9.08266E-04 -3.33544E-07 3.34069E-07 -1.29523E+02 5.12523E-06 9.08280E-04 -6.0835EE+01 ¥ 0 FREQUENCY( 2.-2 )= 1.58576E-08 9.08266E-04 SECOND ORDER: . N M PORT ND

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PHAST DEC

MAGNITUDE

IMAGINARY

REAL

20LDG MAG

MAGNITUDE

IMAGINARY

REAL

DUTPUT UDLTAGE TRANSFER FUNCTION

130.00 PYASE DEC PXASC DEG -8.20584E-16 0 8.205842-16 9.02404E-04 0 9.02404E-04 MAGNITUDE MAGNI TUDE OUTPUT VOLTAGE IMAGINARY IMAGINARY REAL REAL -8.20584E-16 -3.01718E+02 9.02404E-04 -6.08320E+01 -6.08320E+01 20LOG MAG ZOLOG MAG FREQUENCY( 1, 1, 1 )= 1.890E+08 HZ MAGNITUDE MAGNI TUDE TRANSFER FUNCTION IMAGINARY IMAGINARY REAL REAL THIRD ORDER: n n PORT D PORT MO

## 1.62607E-05 6.71497E-06 OUTPUT VOLTAGE -6.58413E-07 6.67339E-06 1.62474E-05 7.46111E-07 -2, 533555-05 6, 50430E-05 -8, 37350E+01 2, 66838E-05 2, 68539E-05 -9, 14179E+01 ¥ FREQUENCY( 1, 1, 2)= 1.893E+08 TRANSFER FUNCTION

6.493966-05 2.98444E-06

n n

THIRD ORDER:

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-2.09818E-05 4.848442-05 1.99373E-05 2.00667E-05 **MAGNITUDE** IMAGINARY 4.84390E-05 2.27461E-06 REAL -2.73758E-06 6.46458E-05 -8.37892E+01 2.65831E-05 2.67556E-05 -9.14517E+01 20LOC MAG MAGNITUDE IMAGINARY 5.45353E-05 3.03281E-05 REAL 

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FREQUENCY( 1, 1.-1 )= 6.300E+07

TRANSFER FUNCTION

-2. 49 83. 49

DUTPUT VOLTAGE

PHASS DEG

THIRD ORDER:

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| 5555<br>1995<br>1995<br>1995<br>1995<br>1995<br>1995<br>1995 | - 20<br>- 20<br>- 20<br>- 20<br> |                 |                   | E CERE              |                                                                                  |                             |            | 500<br>100<br>100<br>100<br>100<br>100<br>100<br>100<br>100<br>100 | 50<br>90                                                                   |                 |           |                              |                                              |                 |            | PLASE<br>LEG                 | -100.20<br>-53.53            |                      |           | PRASE<br>DEG       | ••••••  |
|--------------------------------------------------------------|----------------------------------|-----------------|-------------------|---------------------|----------------------------------------------------------------------------------|-----------------------------|------------|--------------------------------------------------------------------|----------------------------------------------------------------------------|-----------------|-----------|------------------------------|----------------------------------------------|-----------------|------------|------------------------------|------------------------------|----------------------|-----------|--------------------|---------|
| MAGNITUDE                                                    | 4.405005-05<br>3.483585-05       |                 | autput voltagi    | TACKITURE           | -4.127415-05 4.278525-05<br>-4.135072-05 3.438582-05<br>-3.135072-05 3.438582-05 | 10E                         | EGUTTURAN  | 4.050502-03<br>1.550552-03                                         |                                                                            | 394.            | RAGNITUDE | 8.700001-03<br>6.830240-03   |                                              | AGE             | nagni tude | 8.716401-05<br>6.852552-05   |                              | AGE                  | MAGNITUDE |                    |         |
| IMAGINARY                                                    | -4. JE2022-05<br>-3. 123232-05   |                 |                   | Inacinary           |                                                                                  | מעדפעד עמיים                | I MAGINARY | -2.215505-05<br>1.23551E-05                                        |                                                                            | מעדפעד עמים     | IMAGINARY | -6.201285-03<br>-6.155885-05 |                                              | նՍԴРՍԴ ՍՕԼԴ     | Imasinary  | -8.226895-05<br>-6.164276-05 |                              | 0UTPUT V <b>0L</b> 1 | IMAGINARY |                    |         |
| REAL                                                         | -1.457332-05                     |                 |                   | LEAL                | -1.443765-05<br>-1.443765-05<br>1.552703-05                                      |                             |            | REAL                                                               | 4.81372E-05<br>2.310592-05                                                 |                 |           | FEAL                         | -2,010535-05<br>3,023585-05                  |                 |            | PEAL                         | -2.875932-05<br>3.01624E-05  |                      |           | REAL               |         |
| ZOLOG MAG                                                    | -3,461285+01<br>-3,565126+01     | ZH 20+.         |                   | 20LOC MAG           | -8.453542+01<br>-3.652362+01                                                     | :+03 HZ                     |            | 2010G MAG                                                          | -8.384245+01<br>-9.148545+01                                               | -+07 HZ         |           | ZOLOG MAG                    | -a.46353E+01<br>-a.57953E+01<br>-a.57953E+01 | C+07 HZ         |            | ZOLDG MAG                    | -3,47151£+01<br>-3.57919E+01 | ZH 80+3              |           | SOLDG MAG          |         |
| MAGNI TUDE                                                   | 5.37973E-05<br>4.64451E-05       | 2 )= 6.275E     | TRANSFER FUNCTION | RIGHTUDE            | 5.230106-05<br>4.55457E-05<br>5, 2 )= 1.335E                                     | FUNCTION                    | MAGNITUDE  | 6.425115-05<br>2.55521E-05                                         | 2.~1 )= 5.325                                                              | R FUNCTION      | MAGHITUDE | 5.3643325-05<br>4.57283E-05  | 22)= 5.300                                   | · FUNCTION      | MAGNITUDE  | 5.31093E-05<br>4.57513E-05   | · 2)= 1.837E                 | PUNCTION             | MAGNITUDE |                    |         |
| red inres                                                    | -5.54923E-05                     | FREQUENCYC I. I |                   | LAGUIDENI<br>VARAZY | -5.503215-05                                                                     | FREQUENCY 1. 2.<br>TRANSFER | TRANSFER   | Inaginary                                                          | -2.553335-05<br>-2.54724E-05                                               | FREQUENCY( 1. 2 | TRANSFER  | IMAGINARY                    | -5,524192-03                                 | FREDUENCYC 1. 2 | TRANSFER   | IMAGINARY                    | -5.434525-05<br>-4.105522-05 | FREDUENCY( 2, 3      | TRANSFER  | IMAGINARY          |         |
| REAL                                                         | -1.942105-05<br>2.055066-05      |                 |                   | PEAL                | -1.523022-03                                                                     |                             |            | FEG.                                                               | 5.416255-03<br>5.416255-03<br>3.030782-03                                  |                 |           | ∵bΞà                         | -1.540555-05<br>2.015722-05                  |                 |            | LEAL                         | -1.910335-05<br>-1.010335-05 |                      |           | REA'.              |         |
| PCRT<br>1(0                                                  | aim                              | THIZD ORDER:    |                   | 7021<br>10          | ຸດຕ                                                                              | THIPD CRDER:                |            | PCRT<br>PCRT                                                       | 19<br>19<br>19<br>19<br>19<br>19<br>19<br>19<br>19<br>19<br>19<br>19<br>19 | THIRD CROEP:    |           | PORT<br>NO                   | ເດຍ                                          | THIRD ORDER:    |            | Р<br>С<br>С<br>С<br>С<br>С   | .0107                        | THIRD CRIER:         |           | TSD4<br>Or:<br>Or: | • • • • |
| 378255-05       -3.118935-05       5.383565-01       1.594565-05       -7.973335-07       1.556475-05         FREQUENCY       2.6539456-05       -9.151895401       7.820916-07       6.537365-06       6.537365-06         FREQUENCY       2.0-1       1.6.3506476-05       -9.151895401       7.820916-07       6.537365-06       6.537365-06         FREQUENCY       2.0-1       1.6.3506407       MZ       DUTPUT UDLTAGE       0       0         TRANSFER FUNCTION       0       0       0       0       0       0       0         REAL       1       MAGINARY       MAGNITUDE       20L05 MAG       REAL       1       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0       0 |
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 Sec. 1

INPUT FREQUENCIES: FREQUENCY UALUE( HZ)

3.300E+07

8.3255+07 N -

¥ 8.300E+07 TRANSFER FUNCTION FREGUENCY( 1 )= FIRST DRDER:

DUTPUT VOLTAGE

65 65 F -179.78 72,930 5150 PPASS DEG 1.151742-02 3.503362-01 1.165542-02 3.506382-01 MAGNI TUDE **MAGNITUDE** DUTPUT VOLTAGE -1.543502-05 -8.172162-02 -4.50392E-05 -8.15271E-02 IMAGINARY IMAGINARY -1.161735-02 -1.165635-02 3.41029E-01 REAL REAL -::542572-05 1:151742-72 -3.869795+01 -::542572-05 3.503352-01 -9.110302+00 -3.853905+01 -3.853905+01 -9.102815+00 20LOC MAG 20LDG MAG ¥ -4.503925-05 1.153545-02 -8.152715-02 3.565365-01 3.3235+07 MAGNITUDE MAGNI TUDE TRANSFER FUNCTION דתבמטבאכע( 2 )= IMAGINARY IMAGINARY -1.151732-02 -0.405732-01 -1.165525-02 3.410232-02 FEAL PEAL FIRST DRDER: P021 PCR 0 ....

-54.47 -54 04 PP/ASE DEC P14533 535 FKAST DEG 8.844555-03 8.871265-04 -1.555305-04 1.761575-04 -1.417625-03 1.775552-03 MAGNITUDE HACNITUDE MAGNITUDE DUTPUT VOLTAGE DUTPUT UDLIAGE OUTPUT UOLTAGE -7.572555-05 -7.080685-04 IMAGINARY IMAGINARY IMAGINARY 3.830352-05 5.344452-04 7.592305-05 1.066402-03 FEAL PEA' FEAL -1.117535-04 1.731575-04 -7.503155401 -1.117535-03 1.775555-03 -5.502125401 -1.534512-04 1.733325-04 -7.504555401 -1.534512-04 1.733325-04 -7.504555401 -1.415142-03 1.774565-03 -5.501375401 23LCC MAG 20LOG MAC ZOLOG MAG 0 HZ Ξ FPEQUENCY( 1, 1 )= 1.5505+03 MZ FPEOUSHCY( 1, 2 )= 1.532E+08 THORY TUDE IMAGINARY HAGHITUDE IMAGINARY MAGNITUDE TRAUSER FUICTION דתמווגדבת דטווכדוסו TRAMSFER FUNCTION במבסתבאכאנ וי-ו )= 1 60-2021-03 2 602002-03 7.650702-05 2.053702-03 「ビヨピ」 LEG' SECOND CPDER SECOND CRDER: SECCHD CADER TESS IND 

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0 3.542202-15

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-0.013302-15 -3.093175+02 -3.01305-15 -3.093175+02

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4.25217E-04

0

4.25217E-04 -6.74278E+01 4.25217E-04

0

4.252175-04

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| SECOND ORDER: |                             | FREQUENCY( 2,                | 2 )= 1.565E+               | 08 HZ                        |                              |                                             |                            |                              |
|---------------|-----------------------------|------------------------------|----------------------------|------------------------------|------------------------------|---------------------------------------------|----------------------------|------------------------------|
|               |                             | TRANSFER                     | FUNCTION                   |                              |                              | OUTPUT VOLT                                 | AGE                        |                              |
| PCRT<br>NO    | REAL                        | IMAGINARY                    | MAGNITUDE                  | SOLOG MAG                    | REAL                         | IMAGINARY                                   | MAGNI TUDE                 | PXASE<br>DIG                 |
| ຸດເຕ          | 7.52723E-05<br>1.05390E-03  | -1.53470E-04<br>-1.41912E-03 | 1.734335-04<br>1.77364E-03 | -7.511755+01<br>-5.502275+01 | 3.762645-05<br>5.315505-04   | -7.92349E-05<br>-7.09550E-04                | 8.258102-04                | -54 50<br>-524 50<br>-521 54 |
| SECOND ORDER: |                             | FREDUENCY( 2                 | 1 )= 2,500E+               | 05 HZ                        |                              |                                             |                            |                              |
|               |                             | TRANSFER                     | FUNCTION                   |                              |                              | סטדפטד עם <u>י</u> דו                       | AGE                        |                              |
| PORT<br>NO    | REAL                        | IMAGINARY                    | MAGNITUDE                  | 20105 MAG                    | REAL                         | IMAGINARY                                   | MAGNI TUDE                 | PKASE<br>DEG                 |
| ເທດ           | -1.083795-07<br>4.237335-04 | -1.350375-07<br>3.30224E-05  | 1.73931E-07<br>4.23745E-04 | -1.351925+02<br>-6.74579E+01 | -1.023795-07<br>4.2373355-04 | -1.26037E-07<br>-1.36037E-07<br>3.30224E-05 | 1.729315-57<br>4.237451-04 | -123.54                      |
| SECOND ORDER: |                             | FREQUENCY( 21                | 2)=                        | 0 HZ                         |                              |                                             |                            |                              |
|               |                             | TRANSFER                     | FUNCTION                   |                              |                              | 017PUT V0 <u>1</u> 7                        | AGT                        |                              |

| MAGNITUDE  | 3.205515-15<br>4.210502-04   |                 | FAGE                 | RAGNITUDE  | 4.828555-05<br>3.855635-03   |
|------------|------------------------------|-----------------|----------------------|------------|------------------------------|
| IMAGIMARY  | 00                           |                 | autrut vo <u>r</u> 1 | IMAGINARY  | -3.026435-05<br>3.116025-05  |
| REAL       | -3.30951E-16<br>4.21860E-04  |                 |                      | REAL       | 3.768035-06<br>2.272822-06   |
| ZOLOG MAG  | -3.09505E+02<br>-5.74966E+01 | 2H 80+1         |                      | ZOLOG MAG  | -9.427465+01<br>-9.62341E+01 |
| MAGNITUDE  | 3.30951E-16<br>4.21360E-04   | . 1 )≈ 2.490E   | EUNCTION             | MAGNITUDE  | 1.93313E-05<br>1.54274E-05   |
| I THGINARY | 00                           | FREQUENCY( 1. 1 | TRANSFER             | IMAGINARY  | -1.21057E-05<br>1.24S41E-05  |
| REAL       | -3.30951E-15<br>4.218605-04  |                 |                      | REAL       | 1.50721E-05<br>9.09123E-03   |
| PORT<br>NO |                              | THIRD CRDER:    |                      | P0RT<br>N0 | ຸດຕ                          |

130.00

PKAST DEG

# -3.026435-05 4.826255-05 3.116025-05 3.855052-03 OUTPUT VOLTAGE 3 2.272825-06 9.09123E-03 1.24S41E-05 1.54274E-05 -9.62341E+01 FREQUENCY( 1, 1, 2)= 2.433E+03 HZ TRANSFER FUNCTION

THIRD CRDER:

-03.77 53.60

FRAGE Deg

| PORT<br>110  | PEAL                       | IMAGINARY                    | MAGNITUDE   | 20LDC MAG                    | REAL                       | IMAGINARY                   | MAGNITUDE   | 72355<br>72355<br>72555 |
|--------------|----------------------------|------------------------------|-------------|------------------------------|----------------------------|-----------------------------|-------------|-------------------------|
| លក           | 1.49771E-05<br>9.104295-05 | -1.209195-05<br>-1.242835-05 | 1.54052E-05 | -9.431185+01<br>-9.52461E+01 | 1.122285-05<br>6.828222-06 | -9.068905-05<br>9.321155-05 | 1.155452-05 | -22-<br>52-53<br>52-53  |
| THIRD ORDER: |                            | FREQUENCY( 1. 1.             | 1 )= 8.300E | 2H 20+                       |                            |                             |             |                         |

DUTPUT UDLIAGE

TRANSFER FUNCTION

And a state of the second

53, 53 53, 53 -121.65 197.03 121, 77 153, 30 121 74 1982 1982 1983 PKAGE LEG PX955 7.56 PHASE DEG 19974 19974 10071d 10071d 3.042355-05 1.693882-05 3.055341-05 1.684081-05 1.502072-05 8.420342-05 1.527075-05 8.404035-03 1.116192-05 -9.053275-05 1.437512-05 6.837935-06 9.294405-05 1.155525-05 MAGNI TUDE MAGNITURE MAGNITUDE RAGNITUDE MAGNITUDE THEN TUDE OUTPUT UOLTAGE OUTPUT VOLTAGE OUTPUT UDLTAGE DUTPUT VOLTAGE OUTPUT VOLTAGE -2.555455-05 3.527955-05 -2.585522E-05 3.43418E-06 -1.259345-05 1.593485-05 -1.303595-05 1.682872-05 IMAGINARY IMAGINARY IMAGINARY IMAGINARY IMAGINARY IMAGINARY -1.6131SE-05 -1.64747E-05 -1.60182E-05 -1.65870E-05 -8.013115-06 -8.251632-06 -8.064576-06 -8.258626-06 REAL REAL PEAL REAL REAL REAL -9.33240E+01 -9.30114E+01 -1.20778E-05 1.31557E-05 -9.43490E+01 1.239252-05 1.53850E-05 -9.62580E+01 -1.07545E-05 -1.73030E-05 2.03723E-05 -9.33189E+01 -1.05331E-05 2.35137E-05 1.12321E-05 -9.83907E+01 -1.72435E-05 2.02224E-05 -3.38576E+01 2.28945E-06 1.12325E-05 -9.39442E+01 2.04335E-05 -9.37305E+01 1.12372E-05 -9.89364E+01 ZOLOG MAG ZOLOG MAG ZOLDC MAC 20LOG MAC 20LOG MAG ZOLOG MAC ЧZ ¥ ¥ ¥ FREQUENCY( 1. 2.-1 )= 8.325E+07 HZ FREQUENCY( 1, 2,-2 )= 8.300E+07 FREQUENCY( 1, 1,-2)= 8,275E+07 FREQUENCY( 2, 2, 2)= 2,498E+08 FREQUENCY( 1, 2, 2)= 2.495E+03 -1.733255-05 2.035105-05 2.124645-05 1.120545-05 MAGNITUDE **JULI TUDE** MAGNITUDE MAGNI TUDE MAGNI TUDE MAGNI TUDE TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION TRANSFER FUNCTION IMAGINARY -1.738255-05 2.243835-05 IMAGINARY IMAGINARY IMAGINARY IMAGINARY IMAGINARY -1.07529E-05 -1.10115E-05 -1.06341E-05 -1.10022E-05 1.483255-05 9.11724E-05 -1.067832-05 -1.105802-05 REAL REAL REAL REAL REAL REAL THIRD ORDER: THIRD ORDER: THIRD ORDER: THIRD ORDER: THIRD ORDER: 204 204 200 204 PORT FOO PORT 10 PCR1 NO NO NO n w PCR1

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| លល                                           | 1.47884E-05<br>9.13013E-05                   | -1.205355-05<br>1.235695-05        | 1.90847E-05<br>1.53640E-05  | -9.43863E+01<br>-9.62699E+01                 | 3.69711E-06<br>2.282535-06                   | -3.015905-05<br>3.08922E-05 | 4.771155-05<br>3.641091-05 | -09.81<br>53.54                                              |
|----------------------------------------------|----------------------------------------------|------------------------------------|-----------------------------|----------------------------------------------|----------------------------------------------|-----------------------------|----------------------------|--------------------------------------------------------------|
| 'HIRD ORDER:                                 |                                              | FREQUENCY( 2. 3                    | 21 )= 8.350E                | ZH 20+                                       |                                              |                             |                            |                                                              |
|                                              |                                              | TRANSFER                           | REUNCTION                   |                                              |                                              | OUTPUT VOLT                 | EDE:                       |                                                              |
| PORT                                         | REAL                                         | IMAGINARY                          | MAGNITUDE                   | 20LOG MAG                                    | REAL                                         | IMAGINARY                   | RAGMITUDE                  | 010<br>010                                                   |
| g inn                                        | -1.073515-03                                 | -1.722375-05<br>2.459072-05        | 2.03054E-05<br>1.12271E-05  | -9.334745+01<br>-9.339475+01<br>-9.839475+01 | -8.067065-06<br>-8.215855-06                 | -1.291785-05<br>1.844305-05 | 1.625532-03<br>0.4802.5-05 | -181<br>-181<br>-181<br>-181<br>-181<br>-181<br>-181<br>-181 |
| THIRD CRDER:                                 |                                              | FREQUENCY( 2, 2                    | 2,-2)= 8.325E               | ZH 20+:                                      |                                              |                             |                            |                                                              |
|                                              |                                              | TRANSFER                           | R FUNCTION                  |                                              |                                              | аитрит каст                 | TAGE                       |                                                              |
| P021                                         | LUEA                                         | <b>ANGHINARI</b>                   | MAGNITUDE                   | 2010G MAG                                    | REAL                                         | IMAGINARY                   | TENT TUGE                  | PX 400<br>PX 400<br>PIC                                      |
| 2<br>•<br>•<br>•<br>•                        | -1-1100111-1-03                              | -1.715455-05<br>4531?2-05          | 2.0203555-05<br>1.133055-05 | -9.333135+01                                 | -8.004938-06<br>-8.004938-06<br>-8.004728-06 | -1.225505-05<br>1.833805-05 | A 51027403<br>8 50024-03   | 167.121                                                      |
| TIME FOR FOR<br>TIME FOR OBT<br>TOTAL EXECUT | MIPG ZCC(SEC)<br>ACHING OUTPUT<br>TONZ (SEC) | 3.9170<br>SPECTPUN(SEC)<br>21.9330 | 13.0210                     |                                              |                                              |                             |                            |                                                              |

**Kanik** 

\*\*\* P R A N C \*\*\* September 1979 VERSION

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#### CHAPTER 5

#### PROGRAMMER'S GUIDE FOR PRANC

#### 5-1. Introduction

The ideas presented in Chapters 2 and 3 have been used to adapt the Volterra series method for computer-aided distortion analysis of circuits with polynomial type conlinear elements. PRANC (<u>Program</u> for <u>Analyzing</u> <u>Nonlinear Circuits</u>), a digital computer program written in FORTRAN IV, is the outcome of this effort. This chapter presents in detail the program structure and the description of the subprograms contained in PRANC. This chapter should be most useful for programmers wishing to modify the program.

Section 5-2 presents the program structure of PRANC. By pointing out the sequence of phases that are involved in a typical analysis run, the interaction between the various subprograms is depicted. The discussion in this section provides an insight into how the "equivalencing" of arrays should be carried out for conserving storage.

Section 4-3 presents the details of each subprogram contained in PRANC. These details include: 1) brief description; 2) glossary of FORTRAN variables; and 3) listing of each subprogram. The contents of this section should aid the programmer in making future modifications to the program.

PRANC has been developed on the CDC 6500/6600 computer at the Purdue University computing facility, and as such certain machine- and librarydependent instructions exist. These system dependent cards in the program are listed in section 5-4. Cards capable of calling equivalent functions can be substituted in their place for adapting the program on a different system.

#### 5-2. Program Structure of PRANC

Before detailing the program structure of PRANC, it is instructive to delineate the sequence of steps that are involved in a typical analysis run when using our computational algorithms. The program structure and its modularity are better understood once a knowledge of the sequence of steps has been acquired. Referring to a collection of steps as a phase, the following is a partitioning of phases that are involved in a typical analysis run:

Phase A: The following functions are performed during this phase:

(a) Read input data

(b) Control the interaction between the other phases.

In a sense, this phase can be regarded to extend during the entire analysis run.

<u>Phase B</u>: The user desired options are scanned during this phase and the flag variable associated with each option is appropriately set.

Phase C: This phase is responsible for the following functions:

- (a) Setting up of the arrays for the network description in a prescribed manner.
- (b) Assigning addresses based on the user-specified options and the nonlinear element topology.

<u>Phase D</u>: The Hybrid analysis, which yields the constraint matrix [20], is performed during this phase.

<u>Phase E</u>: The state space representation for the linearized circuit is ob-

<u>Phase F:</u> The eigenvalue-eigenvector information is determined from the state space description during this phase.

<u>Phase G</u>: The printing and the formation of the entries of the open-circuit impedance matrix is carried out during this phase.

Phase H: The first-, second-, and third-order transfer functions are computed during this phase.

Phase I: The following functions are performed during this phase:

- (a) Compute the output voltages at each frequency point from the transfer function values.
- (b) Print both the transfer function and the output voltage values at each discrete frequency point for the requested outputs.

<u>Phase J</u>: During this phase, the complete output spectrum at the userrequested port is printed and plotted.

<u>Phase K</u>: When a frequency sweep capability is requested, this phase is used to perform the said operation.

<u>Phase L</u>: When devices, such as transistors, diodes, etc., are to be represented by equivalent nonlinear models, this phase is used to calculate the parameters of the nonlinearities.

Several subroutines are required to perform the functions belonging to each of the aforementioned phases. PRANC, in its present version, consists of thirty-six sub-programs, whose interaction is depicted in Fig. 5-1. In order to provide a link between a phase and its associated sub-programs, the naming of the subroutines has been done in a deterministic manner: the first letter of the subroutine name signifies the phase to which it belongs.



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Thus, for example, the subroutines HORDR1, HORDR2, HORDR3 perform the functions outlined under phase H.

In the following paragraphs the function of each subprogram appearing in Fig. 5-1 is outlined:

Program AMAIN is the executive calling program of PRANC.

Subroutine BOPTNS deciphers the desired user options.

<u>Subroutine CAGMNT</u> forms the augmented linear network by lumping the linear parts of the nonlinear elements with the existing linear network.

<u>Subroutine CRDPRT</u> identifies and combines the parallel energy storage elements and current sources appearing in the augmented linear network, thus effectively reducing the number of ports extracted for hybrid analysis.

<u>Subroutine CSORT</u> sorts the elements of the augmented linear network and arranges them in an order suitable for choosing a proper tree [20].

Subroutine CXTPRT adds a branch to the linear network.

Subroutine DFIREE finds the proper tree from the incidence matrix [20].

<u>Subroutine DHYBRD</u> is the executive calling program for performing hybrid analysis of the augmented linear circuit to obtain the constraint matrix.

<u>Subroutine DIAECH</u> is used to manipulate the incidence matrix into echelon form.

<u>Subroutine DPRINT</u> prints the entire constraint matrix whenever the debug option is requested by the user.

<u>Subroutine DPRNT1</u> prints only part of the constraint matrix describing the port equations whenever the debug option is requested by the user.

<u>Subroutine DRAECH</u> operates on the rows of the hybrid matrix to reduce it into echelon form.

<u>Subroutine ESTATE</u> formulates the state space description of the augmented linear network and, if desired by the user, prints this description.

<u>Subroutine FBALNC</u> balances the matrix whose eigenvalues are to be determined.

<u>Subroutine FEVEV</u> is the executive calling program used to determine the eigenvalues and their associated eigenvectors.

<u>Subroutine FBKXM1</u> is used to back transform the eigenvectors of an Hessenberg matrix.

<u>Subroutine FBKXM2</u> is used to back-transform the eigenvectors of a balanced matrix.

<u>Subroutine</u> <u>FERTST</u> is used to print the error diagnosis arising in eigenvalues-eigenvectors problems.

<u>Subroutine FQRALG</u> determines the eigenvalues and the eigenvectors of the Hessenberg matrix.

Subroutine FRDHSS reduces a matrix to the Hessenberg form.

<u>Subroutine GZOC</u> forms the matrices used to store the entries of the open circuit impedance matrix.

<u>Subroutine GZOCPR</u> prints the entries of the open circuit impedance matrix whenever desired by the user.

<u>Subroutine HORDR1</u> computes the first-order transfer function at each positive and negative input frequency value.

<u>Subroutine HORDR2</u> computes the second-order transfer function at each frequency combination appearing in the second-order output spectrum.

<u>Subroutine HORDR3</u> computes the third-order transfer function at each nonnegative frequency combination appearing in the third-order output spectrum.

<u>Subroutine IWR1ST</u> determines the first-order output spectrum and prints it along with the first-order transfer function at the user-specified output ports.

<u>Subroutine IWR2ND</u> determines the second-order output spectrum for nonnegative frequencies and prints it along with the second-order transfer function values at the user-specified output ports.

<u>Subroutine IWR3RD</u> determines the third-order output spectrum for nonnegative frequencies and prints it along with the third-order transfer function values at the user-specified output ports.

<u>Subroutine JSPCTM</u> performs histogram analysis of all output frequency components and combines the common-ones. It also prints and plots the complete output spectrum at the user-requested port, whenever desired.

Subroutine JPLTSP perform the actual plotting of the output spectrum.

Function JLCOMP locates the data points for plotting.

Function JPUT also locates the data points for plotting.

<u>Subroutine JSEP</u> separates the alphabets in the y-axis label for vertical printing.

ĥ

<u>Subroutine KFRNC</u> computes the frequency increments for each input frequency whenever the frequency sweep capability is requested.

<u>Subroutine KFRVLS</u> computes the new frequency values during the frequency sweep.

<u>Subroutine LTRANS</u> computes the coefficients of the polynomials representing the nonlinear elements in a bipolar transistor.

#### 5-3. Glossary and Subprogram Listings for PRANC

In this section we shall present the specific task of each sub-program, along with its listing. The glossary of important FORTRAN variable names is included in the sub-program listing.

#### 5-3.1 Program AMAIN

Program AMAIN is the executive calling program of PRANC. Its primary function is to read and write input data, to form appropriate arrays for the augmented linear network description, and to assign appropriate addresses for subsequent use in forming the nonlinear current sources. The addressing array NCONT used in PRANC deserves some explanation.

Based on the network element types, and their associated KEY values, the elements of the augmented linear network are arranged in the following order:

- 1. Capacitors
- 2. VCVSs
- 3. CCVSs
- 4. Resistors
- 5. Inductors
- 6. VCCSs
- 7. CCCSs
- 8. Independent current sources

Such an arrangement is warranted for the selection of a proper tree and the formulation of hybrid and state equations. The number of independent current sources is equal to the number of extracted ports, p, for the augmented linear network.

Initially, as each input information card is read, a zero-valued current source is applied across each prescribed input source branch, output branch, nonlinear element branch, and nonlinear element characteristic controlling branch (in the dependent nonlinear element case). Each zero-valued current source signifies an extracted port. Associated with each extracted port is an index number, NCONT, starting from 1 to n ( $n \ge p$ ). Clearly some of the initially extracted ports may be in parallel. The p-port augmented linear network is obtained after the parallel zero-valued current source branches in the n-port network are combined.

The extracted ports in the p-ports network has the following arrangement:

Input port NCONT(1) Output port 1 NCONT(2) Output port 2 NCONT(3) . . Output port k NCONT(k+1) Nonlinear element #1 port NCONT(k+2) Nonlinear element #1 controlling port Nonlinear element #2 port Nonlinear element #2 controlling port

Nonlinear element #2 controlling port

Nonlinear element ## port Nonlinear element ## controlling port Nonlinear element ## controlling port NCONT(3±++1)

The array NCONT contains the port number for each of the above extracted ports. Thus, NCONT(1) contains the port number for the input source port; NCONT(2) for the first output port; NCONT(3) for the second output port; NCONT(k+1) for the k-th output port; and so on. It should be noted that the independent nonlinear elements are treated as special cases of dependent nonlinear elements. Thus, if NCONT(5) = 3 signifies port number 3 for a nonlinear capacitor, then the locations NCONT(6) and NCONT(7) will also contain 3. In the case of a dependent nonlinear element, the number for the controlling ports will usually be different. It should be clear from the above discussion that, for a single input, k-output network with l nonlinearities, the length of the array used is (3l+k+1). The array NCONT plays an important role when the various order steady-state responses are computed.

## 5-3.2. PRANC Listing:

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| [******     | ******                                                                                                                               | *AMN                 | 10        |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------|----------------------|-----------|
| [******     | ***************************************                                                                                              | *AMN i               | 50        |
| [******     | ****** PROGRAM FOR ANALYZING NONLINEAR CIRCUITS *************                                                                        | +AMN :               | 30        |
| C≈≈≈≈≈≈≈    | 医含化合物 化化合物 化化合物 化化合物 化化化合物 化化化合物 化化合物化化合物 化化合物化化合物                                                                                   | *AMN (               | 40        |
| [*******    | **************************************                                                                                               | *AMN                 | 50        |
| [\$4\$4\$50 | <b>医学家学校学校学校学校学校学校学校学校学校学校学校学校学校学校学校学校学校学校学</b>                                                                                      | +*AMN I              | 60        |
| C*******    | <b>环球运输器 建建橡胶的 化化化化化 化化化化化化化化化化化化化化化化化化化化化化化化化化化化化化</b>                                                                              | *AMN                 | 70        |
| PR          | ROGRAM AMAIN(INPUT, DYTPUT, TAPE5=INPUT, TAPES=DUTPUT)                                                                               | AMN 1                | 80        |
| [******     | <b>医输出性管膜炎 化合体管体管 医中心的 网络拉拉拉 经公共公共 的复数的 计成为数据 化合体化合体 化合体化合体化合体化合体</b>                                                                | *AMN                 | 20        |
| C *         |                                                                                                                                      | *AMN 1               | 00        |
| C******     | THIS SUB-FROSRAM PERFORMS THE FOLLOWING FUNCTIONS:                                                                                   | #AMN 1               | 10        |
| C *         | 1. READ AND WRITE IMPUT CIRCUIT DESCRIPTION.                                                                                         | #AMN 1               | 20        |
| C *         | 2. ACT AS THE EXECUTIVE CALLING PROGRAM FOR PRANC.                                                                                   | *AMN 1               | 30        |
| C *         |                                                                                                                                      | *AMN 1               | 40        |
| C*****      | THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINES:                                                                                     | *AMN 1               | 50        |
| U *         |                                                                                                                                      | *AMN 1               | <u>60</u> |
| U a         | 2. CASMAD CRAPRA CREPRA CSCRA                                                                                                        | *ANN 1               | 70        |
|             | J. EAVERD                                                                                                                            | *AMN 1               | 80        |
| C 0         | 9. (23)0).2                                                                                                                          | *AMN 1               | 90        |
| C *         | 5. (1920                                                                                                                             | *AMN 2               | 00        |
|             |                                                                                                                                      | *AMN 2               | 10        |
| L *         |                                                                                                                                      | *AMN 2               | 50        |
|             | 0. 10(15), 10(20), 10(20)                                                                                                            | *AMM 2.              | 0ك        |
| L *         |                                                                                                                                      | *HMPL 2              | 40        |
|             | 10. RERAIDS RERUES                                                                                                                   | * 111 2              | 50        |
|             | 11. LINNAS                                                                                                                           | *61313 21            | 50        |
| C *         | IS WARE STOOD ASSAULTBRAKE REPENDENT KOOTINE)                                                                                        | *HINA C              | 70        |
| C           | TUTO CUR FRANKER OLOGOARU DE FORTRAN NOMES.                                                                                          | *BIND 20             | 20        |
| [*********  | THIS EDEFICIORATES GEUSSARY OF FORTRAL MARIEN                                                                                        | *FUIN C              | 50        |
| ι ···       | LARK) - LARKON KONDER KIN OME HUGDENTED LINEHK                                                                                       | *RINN 3              | 100       |
|             | NERENKA - FORMALA NORE NUMBER FOR ROANDU NUMBER K                                                                                    | *HIMH 3              | 10        |
|             |                                                                                                                                      | *HUTH D              | 20        |
|             | HIULKY · PIOYLETTINOSE HIDSEK FOK BARNDET NONSEK K                                                                                   | *MIN 3               | 40        |
| ن<br>۲۰     | THELEVI - DEMENDINGER VELENENTITE<br>Desminary - Demendinger Velenentiter<br>Desminary - Demendinger für Bonnen Minners Ede Bonnen M |                      | 40<br>50  |
| с »<br>Г »  | KERTAN - CONTRELLING BRANCH NONDER FUR BRANCH N                                                                                      | *HILLI D.<br>*OMN 31 | 50<br>60  |
| r s         | HALLERY - REFAMENT HALLE FOR DANNEL K                                                                                                | *AMN 3               | 20        |
| r a         | CHILLING - CLINING OF MONITIES FOR EXENT Y                                                                                           | KOMN 2               | 20        |
| С а         | DEFINITION OF THE OF THE CENTRE FOR NON INFOR                                                                                        | *AMN 3               | จก        |
| r #         |                                                                                                                                      | KAMN 4               | ñň        |
| r 0         |                                                                                                                                      | KAMN 4               | 10        |
| r a         | CURATO I T-TH INDUT ERECUENCY AND ITHE                                                                                               | *AMN 4               | 20        |
| n »         | REART(I) : I-TH TRAIT FREQUENCY REASE                                                                                                | *AMN 4               | 30        |
| r a         |                                                                                                                                      | *ANN 4               | 40        |
| Č *         | 0 : UNCIDENCE MANRIX FOR THE AUGMENTED LINEAR                                                                                        | KAMN 4               | 50        |
| n a         | NFTUDRK                                                                                                                              | *AMN 4               | S0        |
| C *         | CMC : CONSTRAINT (HYERID) MATRIX                                                                                                     | *AMIN 4              | 70        |
| Č *         | REATER : READING VECTOR FOR THE CONSTRAINT MATRIX                                                                                    | *AMN 4               | 80        |
| Č *         | TKT.11 : LORK MATRIK USED IN HYDRID ANALYSIS                                                                                         | *AMN 4               | <u>90</u> |
| Ŭ *         | EXTRE : HORK HATRIX USED IN HYBRID ANALYSIS                                                                                          | *etti 5              | 00        |
| ë s         | CMAT : MATRIX A OF THE STATE SPACE REPRESENTATION                                                                                    | *AMD 5               | :0        |
| ¢ *         | DIAT : HATRIX 3 OF THE STATE SPACE REPRESENTATION                                                                                    | *AITH 5              | 20        |
| C #         | CHAT : MATRIX C OF THE STATE SPACE REPRESENTATION                                                                                    | *AMH 5               | 30        |
| C *         | DINT : MANDAN D OF THE STATE SPACE REPRESENTATION                                                                                    | *AMH 5               | 40        |
| C 3         | EUNISCID : THTH COMPLEX EIGENHALUE (MATURAL FREQUENCY)                                                                               | *AMH 5               | 50        |
| C 0         | EVENTS : HOBAL MATRIX FOR SIMILARINY TRAMSFORMATION                                                                                  | #AMN 5               | 60        |
| 6 8         | EMAL : MATRIX OBTAILED FROM THE PRODUCT OF MODAL                                                                                     | *AMN 5               | 70        |
| C *         | MATCER RUTERSE AND BMAT                                                                                                              | * AMIL 5             | 80        |
| C *         | CHAT : MARRIE ODTAILED FROM THE PRODUCT OF CMAT AND                                                                                  | *AMH 5               | 90        |
| C #         | 1000-114773                                                                                                                          | #AMN G               | 00        |

Sec. Sec.

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| С                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | WK1,WK2                                                                                                                                                                                                          | : WORK ARRAYS                                                                        | *AMN                                                                                                                                                                                                                                                                                           | 610                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| С                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | NSTPS(I)                                                                                                                                                                                                         | : I-TH INPUT FREQUENCY NUMBER OF INCREMENTS                                          | *ALIN                                                                                                                                                                                                                                                                                          | ē20                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| С                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | FRINC(I)                                                                                                                                                                                                         | : I-TH INPUT FREQUENCY INCREMENT VALUE                                               | *6*4                                                                                                                                                                                                                                                                                           | 630                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| C                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | HFR(I)                                                                                                                                                                                                           | : I-TH INPUT FREQUENCY HIGHEST VALUE                                                 | *AMN                                                                                                                                                                                                                                                                                           | E40                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| C                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | Y1(P,I)                                                                                                                                                                                                          | : PORT P FIRST-GRDER DUTPUT AT FRED(I)                                               | *6MH                                                                                                                                                                                                                                                                                           | 650                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Ç                                                                                                        | ¥                                                                                                                                                                                                                                                                                                                   | W5(I)                                                                                                                                                                                                            | : SECOND-ORDER 1-TH FREQUENCY COMPONENT VALUE                                        | *RMN                                                                                                                                                                                                                                                                                           | 660                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| C                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | Y2(P,I)                                                                                                                                                                                                          | : PORT P SECOND-ORDER OUTPUT AT W2(I)                                                | *6201                                                                                                                                                                                                                                                                                          | 670                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| C                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | FC2(1)                                                                                                                                                                                                           | COMBINATION CODE FOR W2(I)                                                           | *6.001                                                                                                                                                                                                                                                                                         | ES0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| C                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | M3(1)                                                                                                                                                                                                            | : THIRD-ORDER I-TH FREQUENCY COMPONENT VALUE                                         | *AMN                                                                                                                                                                                                                                                                                           | 690                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| C C                                                                                                      | *                                                                                                                                                                                                                                                                                                                   | Y3(P,1)                                                                                                                                                                                                          | : PURI P THIRD-DRDIR DUIPUT AT N3(I)                                                 | *AMN                                                                                                                                                                                                                                                                                           | 700                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Ľ                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | FUS(1)                                                                                                                                                                                                           | : FREQUENCY CONSINATION CODE FOR N3(I)                                               | MAA*                                                                                                                                                                                                                                                                                           | 710                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| L<br>C                                                                                                   | *                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                  | : 1-TH FREUDENCY VALUE IN THE COMPLETE SPECTRU                                       | MARMA                                                                                                                                                                                                                                                                                          | 720                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                                                                                                          | *                                                                                                                                                                                                                                                                                                                   | 7(1)                                                                                                                                                                                                             | · UUTPUT VULTAGE AT FR(T)                                                            | *666                                                                                                                                                                                                                                                                                           | 700                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| č                                                                                                        | *                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                  | · HARAY USED FUR MAISTUGRAMY HAALYSIS                                                | * Filtin                                                                                                                                                                                                                                                                                       | 740                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| L<br>C                                                                                                   | *                                                                                                                                                                                                                                                                                                                   | CTI OTO                                                                                                                                                                                                          | · LUG OF THE OUTPUT LYDE ODE FOR FLOTTING                                            | P Fichi                                                                                                                                                                                                                                                                                        | 150                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| È                                                                                                        | *                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                  | · DUARY STUKRUE AKKAYS USED FUK EBUIVALENLING                                        | *EGH                                                                                                                                                                                                                                                                                           | 760                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| r<br>r                                                                                                   | *                                                                                                                                                                                                                                                                                                                   | ncont                                                                                                                                                                                                            | • NAKAT FUK HUKLODING NUNLINGAK UUKKCHI<br>Rahare amb denherten antont opote (etc    | <ul> <li>PERMIT</li> <li>PERMIT</li> </ul>                                                                                                                                                                                                                                                     | 770                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| ř                                                                                                        | *                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                  | TECHNICAL DEPORT FOR DETAILSY                                                        | - 26 MAN                                                                                                                                                                                                                                                                                       | 700<br>200                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| ř                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | ICONT (Y)                                                                                                                                                                                                        | - RECHARGE REFUKT FUR DETHILD)<br>- RECAND COMPONIA THE RECOVER SAFET FOR MARKED FOR | *nini<br>Asomi                                                                                                                                                                                                                                                                                 | 750<br>800                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| ř                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | Jeomery                                                                                                                                                                                                          | FIENENT KZ SUBSEDUENTLY IDENTIETES THE                                               | nenut<br>Reme                                                                                                                                                                                                                                                                                  | 200                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| č                                                                                                        | *                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                  | NONY INFOR FLEMENT TYPE                                                              | RCMN                                                                                                                                                                                                                                                                                           | 230                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| č                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | TTTLE                                                                                                                                                                                                            | : ARRAY USED FOR READING TITLE AND DETION CARD                                       | *CMN                                                                                                                                                                                                                                                                                           | 520                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| č                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | NCAP                                                                                                                                                                                                             | : NEMBER OF LINEAR CARACTINES                                                        | * OMN                                                                                                                                                                                                                                                                                          | 220                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| č                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | NNUS                                                                                                                                                                                                             | NUMBER OF LINEAR DEPENDENT UN TAGE SOURCES                                           | * CMN                                                                                                                                                                                                                                                                                          | 850                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| ē                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | NRES                                                                                                                                                                                                             | : NUMBER OF LINEGR RESISTORS                                                         | *0001                                                                                                                                                                                                                                                                                          | - ຍວຍ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| ē                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | NIND                                                                                                                                                                                                             | : NUMBER OF LINEAR INDUCTORS                                                         | * AMM                                                                                                                                                                                                                                                                                          | 820                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Ĉ                                                                                                        | *                                                                                                                                                                                                                                                                                                                   | NDCS                                                                                                                                                                                                             | : NUMBER OF LINEAR DEPENDENT CURRENT SOURCES                                         | ≮6MN                                                                                                                                                                                                                                                                                           | 830                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| С                                                                                                        | ¥                                                                                                                                                                                                                                                                                                                   | NCS                                                                                                                                                                                                              | : NUMBER OF LINEAR CURRENT SOURCES(=> OF PORTS                                       | )*60001                                                                                                                                                                                                                                                                                        | 683                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
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| С                                                                                                        | *                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                  |                                                                                      | *台合台                                                                                                                                                                                                                                                                                           | 500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| C<br>C***                                                                                                | *<br>*******                                                                                                                                                                                                                                                                                                        | *****                                                                                                                                                                                                            | ***                                                                                  | 百合34<br>7776**                                                                                                                                                                                                                                                                                 | 200<br>210                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| C<br>C***<br>C                                                                                           | *<br>********                                                                                                                                                                                                                                                                                                       | *****                                                                                                                                                                                                            | ***                                                                                  | [[11] *<br>[11] AMA**<br>[[11] A                                                                                                                                                                                                                                                               | 500<br>510<br>520                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| C<br>C***<br>C<br>C                                                                                      | ********                                                                                                                                                                                                                                                                                                            | ****                                                                                                                                                                                                             | ***                                                                                  | 6263*<br>1926**<br>1926<br>1926                                                                                                                                                                                                                                                                | 500<br>510<br>520<br>530                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| C<br>C***<br>C<br>C                                                                                      | *<br>INTEGER                                                                                                                                                                                                                                                                                                        | A, BR, TYPE                                                                                                                                                                                                      | **************************************                                               | *6661<br>**6148<br>6068<br>6061<br>6068                                                                                                                                                                                                                                                        | 200<br>910<br>220<br>230<br>940                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| C<br>C <del>***</del><br>C<br>C                                                                          | *<br>INTEGER<br>INTEGER                                                                                                                                                                                                                                                                                             | **********<br>A, BR, TYPE<br>R, G, C, E, C                                                                                                                                                                       | **************************************                                               | *689<br>**600<br>6991<br>6991<br>6991<br>6991                                                                                                                                                                                                                                                  | 500<br>910<br>520<br>530<br>530<br>530                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| C<br>C <del>***</del><br>C<br>C                                                                          | *<br>INTEGER<br>INTEGER<br>INTEGER                                                                                                                                                                                                                                                                                  | ***********<br>A, BR, TYPE<br>R, G, C, E, C<br>DB, SE, FS,                                                                                                                                                       | **************************************                                               | * 6579<br>** 6171N<br>65791<br>65791<br>65791<br>65791<br>65791                                                                                                                                                                                                                                | 500<br>910<br>520<br>530<br>540<br>550<br>550                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| C<br>C***<br>C<br>C                                                                                      | *<br>INTEGER<br>INTEGER<br>INTEGER<br>COMPLEX                                                                                                                                                                                                                                                                       | A, BR, TYPE<br>R, G, C, E, C<br>DB, SE, FS, I<br>TH                                                                                                                                                              | **************************************                                               | 4600<br>4000<br>4000<br>4000<br>4000<br>4000<br>4000<br>4000                                                                                                                                                                                                                                   | 500<br>510<br>520<br>530<br>530<br>530<br>530<br>530<br>530<br>570                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| C<br>C <del>***</del><br>C<br>C                                                                          | *<br>INTEGER<br>INTEGER<br>INTEGER<br>COMPLEX                                                                                                                                                                                                                                                                       | A, BR, TYPE<br>R, G, C, E, C<br>DB, SE, FS,<br>TH                                                                                                                                                                | **************************************                                               | * 6000<br>** 6000<br>6001<br>6001<br>6001<br>6001<br>6001<br>6001<br>6001                                                                                                                                                                                                                      | 500<br>910<br>520<br>530<br>530<br>530<br>530<br>530<br>530<br>530<br>530<br>530                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| C<br>C <del>***</del><br>C<br>C<br>C                                                                     | *<br>INTEGER<br>INTEGER<br>INTEGER<br>COMPLEX<br>** ARRAYS                                                                                                                                                                                                                                                          | A, BR, TYPE<br>R, G, C, E, C<br>DB, SE, FS, I<br>TH<br>PEQUIRED                                                                                                                                                  | **************************************                                               | *6779<br>**6770<br>6771<br>6771<br>6771<br>6774<br>6774<br>6774<br>6774<br>6774                                                                                                                                                                                                                | 500<br>910<br>520<br>520<br>520<br>520<br>520<br>520<br>520<br>520                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| C<br>C <del>***</del><br>C<br>C<br>C<br>***                                                              | *<br>INTEGER<br>INTEGER<br>INTEGER<br>COMPLEX<br>** ARRAYS                                                                                                                                                                                                                                                          | A, BR, TYPE<br>R, G, C, E, C<br>DB, SE, FS, I<br>TH<br>PEQUIRED I                                                                                                                                                | **************************************                                               | *6779<br>***070<br>6779<br>6779<br>6779<br>6779<br>6779<br>6779<br>6779<br>6                                                                                                                                                                                                                   | 500<br>510<br>520<br>520<br>520<br>520<br>520<br>520<br>520<br>52                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| C<br>C***<br>C<br>C<br>C<br>C<br>***                                                                     | *<br>INTEGER<br>INTEGER<br>INTEGER<br>COMPLEX<br>** ARRAYS<br>DIMENSI                                                                                                                                                                                                                                               | A, BR, TYPE<br>R, G, C, E, C<br>DB, SE, FS, I<br>TH<br>PEQUIRED<br>ON BR(75),                                                                                                                                    | **************************************                                               | 8768<br>8768<br>8768<br>8768<br>8768<br>8768<br>8768<br>8768                                                                                                                                                                                                                                   | 500<br>910<br>520<br>530<br>530<br>530<br>530<br>530<br>530<br>1000<br>1010                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| C<br>C***<br>C<br>C<br>C<br>C<br>***<br>C<br>C<br>***                                                    | *<br>INTEGER<br>INTEGER<br>INTEGER<br>COMPLEX<br>** ARRAYS<br>DIMENSI                                                                                                                                                                                                                                               | A, BR, TYPE<br>R, G, C, E, C<br>DB, SE, FS, I<br>TH<br>PEQUIRED I<br>ON BR(75),                                                                                                                                  | **************************************                                               | 1008 **<br>1008 **<br>1008 **<br>1008 1008<br>1008 1008<br>1008 10<br>1008 10<br>10<br>10<br>10<br>10<br>10<br>10<br>10<br>10<br>10<br>10<br>10<br>10<br>1 | 500<br>510<br>520<br>520<br>520<br>520<br>520<br>520<br>520<br>520<br>520<br>52                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| C<br>C***<br>C<br>C<br>C<br>C<br>***<br>C<br>C<br>C<br>***<br>C<br>C                                     | *<br>INTEGER<br>INTEGER<br>INTEGER<br>COMPLEX<br>** ARRAYS<br>DIMENSI                                                                                                                                                                                                                                               | A, BR, TYPE<br>R, G, C, E, C<br>DB, SE, FS, I<br>TH<br>REQUIRED I<br>ON BR(75),<br>FOR ELEMEN                                                                                                                    | **************************************                                               |                                                                                                                                                                                                                                                                                                | 500<br>510<br>520<br>530<br>530<br>530<br>530<br>530<br>530<br>530<br>530<br>530<br>53                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| C<br>C***<br>C<br>C<br>C<br>***<br>C<br>C<br>C<br>***<br>C                                               | *<br>INTEGER<br>INTEGER<br>INTEGER<br>COMPLEX<br>** ARRAYS<br>DIMENSI                                                                                                                                                                                                                                               | A, BR, TYPE<br>R, G, C, E, C<br>DB, SE, FS, I<br>TH<br>REQUIRED I<br>ON BR(75),<br>FOR ELEMEN<br>ON VALUE(7)                                                                                                     | **************************************                                               |                                                                                                                                                                                                                                                                                                | 5000<br>5120<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5200<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000     |
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| C C ****<br>C C ****<br>C C ****                 | <ul> <li>INTEGER<br/>INTEGER<br/>INTEGER<br/>COMPLEX</li> <li>ARRAYS</li> <li>DIMENSI<br/>ARRAYS</li> <li>COMMON</li> <li>INPUT</li> <li>COMMON</li> <li>DIMENSI</li> <li>ARRAYS</li> </ul>                                                                                                                         | A, BR, TYPE<br>R, G, C, E, C<br>DB, SE, FS, I<br>TH<br>PEQUIRED I<br>ON BR(75),<br>FOR ELEMEN<br>ON VALUE(7)<br>FOR NONLII<br>/001/ NTYP:<br>AMPLITUDE (<br>/003/ FRED<br>ON PHASE(5)<br>FOR HYBRI)              | <pre>************************************</pre>                                      |                                                                                                                                                                                                                                                                                                | 5000<br>5100<br>5200<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000<br>5000     |
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| C<br>C<br>C<br>C<br>C<br>C<br>C<br>C<br>C<br>C<br>C<br>C<br>C<br>C                                       | <ul> <li>INTEGER<br/>INTEGER<br/>INTEGER<br/>COMPLEX</li> <li>ARRAYS</li> <li>DIMENSI</li> <li>ARRAY</li> <li>DIMENSI</li> <li>ARRAYS</li> <li>COMMON</li> <li>DIMENSI</li> <li>ARRAYS</li> <li>DIMENSI</li> <li>ARRAYS</li> </ul>                                                                                  | A, BR, TYPE<br>R, G, C, E, C<br>DB, SE, FS, I<br>TH<br>PEQUIRED I<br>ON BR(75),<br>FOR ELEMEN<br>ON VALUE(7)<br>FOR NONLII<br>/001/ NTYP;<br>AMPLITUDE (<br>/003/ FREO<br>ON PHASE(5<br>FOR HYBRI)<br>DN A(30,75 | <pre>************************************</pre>                                      |                                                                                                                                                                                                                                                                                                | 50000000000000000000000000000000000000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| C C ****<br>C C **** | <ul> <li>INTEGER<br/>INTEGER<br/>INTEGER<br/>COMPLEX</li> <li>ARRAYS</li> <li>DIMENSI</li> <li>ARRAY</li> <li>DIMENSI</li> <li>ARRAYS</li> <li>COMMON</li> <li>INPUT</li> <li>COMMON</li> <li>DIMENSI</li> <li>APRAYS</li> <li>DIMENSI</li> <li>APRAYS</li> <li>DIMENSI</li> <li>APRAYS</li> <li>DIMENSI</li> </ul> | A, BR, TYPE<br>R, G, C, E, C<br>DB, SE, FS, I<br>TH<br>REQUIRED I<br>ON BR(75),<br>FOR ELEMEN<br>ON VALUE(7)<br>FOR NONLII<br>/001/ NTYP;<br>AMPLITUDE I<br>/003/ FRED<br>ON PHASE(5<br>FOR HYBRI)<br>DN A(30,75 | <pre>************************************</pre>                                      |                                                                                                                                                                                                                                                                                                | \$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$10000<br>\$100000<br>\$100000<br>\$100000<br>\$100000<br>\$100000<br>\$100000<br>\$100000<br>\$100000<br>\$1000000<br>\$100000000<br>\$10000000000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

| <u>[</u> *****                             | ARRAYS FOR THE FORMATION OF STATE EQUATIONS                       | AMN             | 1210         |
|--------------------------------------------|-------------------------------------------------------------------|-----------------|--------------|
| Ľ                                          | DIMENSION AMAT(20,20), BMAT(20,20), CMAT(25,20), DMAT(25,25)      | AWN<br>AMN      | 1220         |
| C<br>Caaaaa                                | FIGENUAL LE AND FIGENHEATAR ARRAYS                                | AMN             | 1240         |
| C                                          |                                                                   | AMN             | 1260         |
| ~                                          | COMPLEX EVALS(20), EVECTS(20, 20)                                 | AMN             | 1270         |
| د<br>(*****                                | ARRAYS FOR STORING PFE INFO AND NORK ARRAYS                       | AMN             | 1280         |
| С                                          | COMPLEX DMAT(20,23), CHAT(25,20), WK1(20,20), WK2(20,20)          | amn<br>Amn      | 1300<br>1310 |
| C<br>Гараза                                | CORAYS FOR FREMENRY SUFER                                         | AMN<br>AMN      | 1320         |
| č                                          |                                                                   | AMN             | 1340         |
| С                                          | LUMAUA 20042 No Poloj, RAMELOJ, RAKLOJ                            | AMM<br>AMM      | 1360         |
| C*****                                     | ARRAYS FOR FIRST-CRDER TRANSFER FUNCTIONS                         | AMN             | 1370         |
| 0                                          | COMPLEX Y1(25,10)                                                 | RMA             | 1390         |
| C                                          |                                                                   | 6MN             | 1400         |
| (*****<br>C                                | FARRING FUR SECOND-URDER TRANSFER FUNCTIONS                       | - Fillin        | 1410         |
| L<br>L                                     | COMPLEY VO(DE REN HMZ(DE DEN                                      | CMN             | 1420         |
|                                            |                                                                   | - Fillin<br>OMN | 1430         |
|                                            | HANDIOLON RECOV                                                   | CMN             | 1/50         |
| c                                          | Integration (CECO)                                                | AMN             | 1460         |
| C<br>C ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ | ADDANS TO THIDD-CODED TRANSFER FUNCTIONS                          | 6MN             | 1420         |
| C                                          |                                                                   | 6MN             | 1480         |
| 0                                          | CRM215X V3(25,120)                                                | 6MN             | 1490         |
|                                            |                                                                   | AMN             | 1500         |
|                                            |                                                                   | EMN             | 1510         |
| C                                          |                                                                   | AMN             | 1520         |
|                                            | ARRAYS FOR COMPLETE OUTPUT SPECTRUM                               | AMN             | 1530         |
| Ċ                                          |                                                                   | AWN             | 1540         |
|                                            | COMPLEX Y(160)                                                    | AMN             | 1550         |
|                                            | DINENSION FR(160), IPT(160), YLG(150)                             | AMN             | 1560         |
| С                                          |                                                                   | AMN             | 1570         |
| [*****                                     | MISCELLANEOUS HORK ARRAYS                                         | AMN             | 1530         |
| С                                          |                                                                   | AMN             | 1590         |
|                                            | DIMENSION ST1(75,100), ST2(50,225), NLBN(32), TITLE(80), NPORT(25 | MARACE          | 1600         |
| _                                          | COMMON /016/ MCONT(22),JCGNT(10)                                  | AUN             | 1610         |
| С                                          |                                                                   | - ALUA          | 1620         |
|                                            | COMMON 217422 R, G, L, E, 15, E0, 00, UC; 00                      | - FUN           | 1630         |
| ~                                          | COMMON NEWO3/ NCB3, NKE2, UTUD, NC2, NC2                          | - FITT          | 1050         |
| 1.<br>                                     | - FOUTURE FROM PLACE A CORPANN HUDDER MATRIX                      | - AMN           | 1630         |
| - ይ <del>አ</del> ጵጵጵ<br>- ር                | FRAINFEARS FOR NEWSELL (DILATA MARKID MALKIX)                     | - BUILL<br>OMN  | 1650         |
| L                                          |                                                                   | - DOMN          | 1620         |
|                                            | ECOLOMETACE (STITI) TOTIO                                         | CMN             | 1600         |
|                                            |                                                                   | AMN             | 1700         |
|                                            |                                                                   | 6MN             | 1710         |
|                                            |                                                                   | GNN             | 1720         |
|                                            | FRUTUAL FROF (ST1(301), TEANT(1))                                 | AMN             | 1730         |
|                                            | ERUTUALENCE (ST1(373), VALUE(1))                                  | AMA             | 1740         |
|                                            | EQUIVALENCE (\$71(451), KEY(1))                                   | AMA             | 1750         |
|                                            | EQUENALENCE (ST1(525), EXTR1(1))                                  | AMA             | 1760         |
|                                            | EQUIVALENCE (STICEPTED, EXTRECID)                                 | AMA             | 1770         |
|                                            | EBUIUALENCE (ST1(5025)+A(1))                                      | 6MH             | 1780         |
|                                            | ECUIVALENCE (ST1(7273), MEADER(1))                                | AMA             | 1790         |
|                                            | EQUITION ENDE (ST2(1), 095(1))                                    | AWN -           | 1800         |

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C\*\*\*\*\* EQUIVALENCE FOR PHASE 2 (OBTAIN STATE EQUATIONS) C EQUIVALENCE (ST1(SEB),AMAT(1)) EQUIVALENCE (ST1(3015),D1AT(1)) EQUIVALENCE (ST1(3015),D1AT(1)) EQUIVALENCE (ST1(30,EMAT(1)) С C\*\*\*\*\* EDUINALENCE FOR PHASE & (OBTAIN Z(S) IN PFE FORM) С EQUIVALENCE (ST2(2001))(K1(1)) ROUDVALENCE (ST2(201))(K2(1)) HOUDVALENCE (FT2(2001))(K2(1)) HOUDVALENCE (FT2(2001))(FOCTB(1)) EQUIVALENCE (ST2(10))(K1(1)) C Casas ECUIVALENCE FOR FMAGE 4 (OBTACH OUTPUT RESPONSES) С EPUTUALENCE (072(00)1),V1(1)) EPUTUALENCE (072(00)1),V2(1)) EPUTUALENCE (072(0)1),V2(1)) EPUTUALENCE (072(0)1),V2(1)) EPUTUALENCE (072(0)1),V2(1)) EPUTUALENCE (072(0)1),V2(1)) EPUTUALENCE (072(0)1),V2(1)) EPUTUALENCE (072(0)1),V2(1)) C C\*\*\*\*\* EDUIVALENCE FOR PWARE 5 (DBTAIN COMPLETE OUTPUT SPECTRUM) С EQUAVALENCE (071(1)+FR(4)) EQUAVALENCE (071(1)+FR(4)) EQUIVALENCE (071(141)+FR(4)) EQUIVALENCE (071(311)+V16(1)) DATA C.L.F.ISZEN C.EVILSEN E.EM IZ DATA C.L.F.ISZEN C.EVILSEN E.EM IZ DATA C.L.F.ARTHDZENCCZENCLENCE.EMDZ C C\*\*\*\*\* MAM CIRCUIT CONFIGURATION IS 30 NODES AND 75 DRANCHES С CALL SECOND (TO) NKODE=20 NKOR=25 NKOR=25 103210-550 C MAK MONLINEAR ELEMENTS IS 10 (DEPENDENT TYPE LE 5) MAK INDEPENDENT COURCES IS 2 MAK TOTAL CAPACITORS AND INDUCTORS IS 20 (\*\*\*\*\*\* Cossees Caaaaaa С NDAR--0 NREG--0 NTND--0 NCS 40 NCS 40 10030-0 1097-1 110/17=2 C 7.1.1 1.417 F C\*\*\*\*\*\* READ TITLE CARD

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С READ (5,812) (TITLE(J),J=1,80) 0 C\*\*\*\*\*\* WRITE TITLE LINE AND PRINT MEADING OF METWORK DESCRIPTION C (RIVE (6,214) (VERLE(1), 1+1,08) 0 CHANNA READ-MREDODENS (NO URBIE DEGIRED OPTIONS REAR (S-926) (TERUE(D-CARDID) REAR (S-926) (TERUE(D-CADAD) RAUL DERTHS (TERUE)EB-FG-MK-SE,MM-PR-PC-AP) MRTTE (S-926) MRTTE (S-926) MRTTE (S-926) MRTTE (S-926) USSESSO READ ANNLYSIS PARAMETER CARD READ (65,000) MUST END INFELEN AFRED, LUNET, ENTYP NATIONALELEN ANTELEN S\*\*\*\*\* READ LENEAR DERCULT DESCREPTION ċ DO 109 KK=1, NLELEH REND (8, 253) NES, NL, NZ, NT, VAL, ICT, OUTPT, NOT GRARA FERN LENEOR ELEMENT VERELEGY ARRAYS KECHER DRAMPEK DRAMPEK DRAMPERA DRAMPER C CHANNE OF RESECTION CANNER IS AN OUTPUT, EXTRACT IT AS A PORT ċ 

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| ſ       |       |                                                         | KEY(K)=8<br>NDCS=NDCS+1<br>GO TO 110                                                | amn<br>Amn<br>Amn | 2010<br>2020<br>2020 |
|---------|-------|---------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------|----------------------|
| C       | ****  | V                                                       | CVS                                                                                 | enna<br>EMM       | 3050                 |
| С       | 104   |                                                         | KEN(K)-2                                                                            | - AMN             | 2060                 |
|         | 104   |                                                         | NDUS=NDUS+1                                                                         | - Falas<br>- AMN  | 2020                 |
| ~       |       |                                                         | GO TO 110                                                                           | OMN               | 3090                 |
| Ci      | ****  | С                                                       | C U S                                                                               | - FANN<br>- ANN   | 2100                 |
| č       |       | Ŭ                                                       |                                                                                     | 6.MN              | 2120                 |
|         | 106   |                                                         | KEY(K)=4<br>NDUS=NDUS+1                                                             | AMN               | 3130                 |
|         |       |                                                         | GO 70 110                                                                           | - AMN             | 3140                 |
| C .     | ***** |                                                         |                                                                                     | F. C              | 3160                 |
| č       |       | Ŷ                                                       |                                                                                     | 6321              | 2170                 |
|         | 103   |                                                         |                                                                                     | EMN               | 2190                 |
| С       |       |                                                         | 11002-11002+1                                                                       | E FATAL<br>FATAL  | 2200                 |
| C,      | ****  | WF                                                      | RITE DEPENDENT SOURCE BRANCH INFORMATION                                            | F.MN              | 3220                 |
| L       | 110   |                                                         | URITE (6,228) $BR(K)$ , $NEROM(K)$ , $NTO(K)$ , $TYPE(K)$ , $UALUE(K)$ , $TCONT(K)$ | - 6200<br>- 6200  | 0220<br>7540         |
| _       |       |                                                         | GO TO 120                                                                           | F.MO:             | 3250                 |
| <br>€   | ****  | R                                                       | SISTIUT BRANCH                                                                      | EMRI<br>OMN       | 3230<br>3270         |
| č       |       |                                                         |                                                                                     | 6222              | 2280                 |
|         | 112   |                                                         | KEY(K)=5                                                                            | FINIT             | 0835                 |
|         |       |                                                         | GO TO 118                                                                           | ENN.              | 3310                 |
| C       |       | ~                                                       |                                                                                     | 6.521             | 3120                 |
| C<br>C  | ***** | Lf                                                      | THUITIDE BRHNUH                                                                     | - 6222<br>- 6222  | 2220                 |
|         | 114   |                                                         | NCAP≈NCAP+1                                                                         | f.: :::           | 3330                 |
|         |       |                                                         | KEY(K)=2<br>GO TO 118                                                               | EARS<br>EARS      | 2230                 |
| C       |       |                                                         |                                                                                     | E M M             | 2230                 |
| C*      | ***** | II                                                      | IDUCTIVE ERANCH                                                                     | - FANDI<br>ANNI   | 3330                 |
| C       | 116   |                                                         | NIND≈NIND+1                                                                         | E M               | 3410                 |
| c       |       |                                                         | KEY(K)=6                                                                            | 6MN               | 3420                 |
| С*      | ****  | W                                                       | RITE R.L.C BRANCH INFORMATION                                                       | 6 MN              | 2420                 |
| С       |       |                                                         |                                                                                     | F.MPI             | 3450                 |
|         | 113   | 102                                                     | HRITE (6,230) BR(K), NERUM(K), NEU(K), TYPE(K), VALUE(K)                            | - FAIN<br>- FAIN  | 3450<br>2470         |
| C       |       |                                                         |                                                                                     | 6224              | 3480                 |
| C*      | ****  | REF                                                     | NUNLINEAR ELEMENT INFORMATION                                                       | ENN<br>EMN        | 2450<br>7500         |
| -       | ł     | <k=< td=""><td>:0</td><td>£2223</td><td>2510</td></k=<> | :0                                                                                  | £2223             | 2510                 |
|         | ]     | 00                                                      | 123 K=1,NNELEM                                                                      | END!              | 3520                 |
| С       |       |                                                         |                                                                                     | 623N              | 2530                 |
| C*      | ****  | R                                                       | AD NONLINEAR ELEMENT TOPOLOGY                                                       | - Altin           | 3550<br>TVC0         |
| ų       |       |                                                         | READ (5,232) NEG,N1,N2,NT,ICT,JCT                                                   | CI:::             | 3570                 |
| c       |       |                                                         | IF (NT.E0.2HTR) GO TO 126                                                           | $G_{i}^{m}$       | 3380                 |
| с<br>С* | ****  | RE                                                      | AD POLYNOMIAL COEFFICIENTS FOR THE NONLINEARITY                                     | 6111<br>6111      | 0000<br>2000         |

| С         |             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | AMN             | 3510  |
|-----------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------|
|           |             | IF (NT.EO.ND) CO TO 122                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | AMN             | 3850  |
|           |             | READ (5-224) (ECFF(KK, 1), I=1,3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 6HN             | 2830  |
|           |             | 07 TO 124                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | AMA             | 3640  |
|           | 153         | READ (5,223) (DDFF(KK,I),I=1,9)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>RMN</b>      | 2350  |
|           | 124         | NUDINGKO HPEG                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | F.M.M           | 3860  |
|           |             | DR(NEG)= NEG                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <u>AMA</u>      | 3970  |
|           |             | UFRON(UER) MI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | FULLY.          | 3080  |
|           |             | THORATED HAT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 6.PIN           | 3690  |
|           |             | TYPE (ALCO-AF                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | AMM             | 3700  |
|           |             | TODITY (HEG) - TOT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | ANN             | 3710  |
|           |             | 1970017 (1000) - 2007                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 6DN             | 2720  |
|           |             | 69 00 120                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Pina</b>     | 3720  |
|           | 123         | COLL TROODS (MEG. N1, NOBD, KK, N' EN, ER, NEROM, NTO, TYPE, ICONT, VALUE, NO                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | nnet            | 2740  |
|           | · 1         | 10F. (FU)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | CON.            | 3750  |
|           | 123         | C CONTRACTOR CONT                                                                                                                                                                                                                                                | 6121            | 3760  |
|           | ~1-0        | NOTE THREE CONTRACTORS AND A DESCRIPTION OF A DESCRIPTION OF<br>A DESCRIPTION OF A DESCRIPTION | ene.            | 3770  |
| r         |             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | OD:N            | 3780  |
| с.<br>Г.= | ****        | * POINT NOW INTOR ELEMENT INTORNATION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | ON: L           | 3100  |
| ř         |             | - Sector Honzahlens (Edulation) - 110 Berlin 201                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | entre.          | 3200  |
| <u>ل</u>  |             | HRITE (R. PRO)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 6MN             | 2210  |
|           |             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | AMN.            | 2820  |
|           |             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | CNN.            | 5820  |
|           |             | DO PEL A MARCELLI<br>MARCE PER YA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | ONN             | 3870  |
|           |             | THE CHARTER NEW FOUND OF TO 120                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | ONN             | 2250  |
|           |             | UNITED STATES AND MADEMAN STOREN FOREKT 1) CORE(1.3), CORE(                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | CAMA -          | 2000  |
|           | ,           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | ONIN            | 2000  |
|           | 1           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | - 111<br>- 11N  | 2010  |
|           |             | UNDER STATE OF STATE NEROMANN NERONAL TYREAN TRANSLAND TO NATURAL TRANSLAND                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | - 101<br>- 1151 | 2000  |
|           | 1. J        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | CMN             | 2000  |
|           |             | U INCONTUNENCUNUNTUNENCUNUN PRESULEN PRESULEN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | OMN             | 2300  |
|           |             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | CMM             | 2020  |
|           | 100         | CONSTRUCT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | OUN.            | 2020  |
| ~         | 112         | Cunterioz                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | COMPL           | 2000  |
| ار.<br>ا  |             | ACAR AND LOTTE CONCRETER INCOMATION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ADD1            | 2240  |
| ເ∝        | 12.02.02.02 | ACHO MAD VATTI GIAIRATOR INFORMATION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | ONN             | 2000  |
| L         |             | PEAR (5.922) NU NO NE 23                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | ONN.            | 2000  |
|           |             | REHU CONSECUTION DE CONTRA DE C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | NMN.            | 2020  |
|           |             | Transference and the second seco                                                                                                                                                                                                                                                | ONN             | 2000  |
|           |             | 17 UNI-CURED BUILD COST<br>Contractory chorpered there needed nto key ni no c nt 78)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | CIMPL           | 3030  |
|           |             | UNEL CATERIA CONDUCTOR OR UNERTICATED AND AND AND AND AND AND AND AND AND AN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | OND             | 1010  |
|           |             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | OMN             | 2030  |
|           |             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | CH H T          | 4020  |
|           |             | COLL CONTRACT, (NARR RECEVENTION RECOMMENTE REC. NI. NO S. NT. 78)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | OMN             | 10.10 |
|           | 1-1-1       | LOTE LATING (MADD) LK, MEL, OULDE, MERCH, MID, KEY, MIMES J. M. 237                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ONN             | 4040  |
|           |             | Proceeding and the second s                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | ONN             | 4030  |
|           |             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | ONN             | 4050  |
|           |             | UTU ACH<br>Call over the analysis include Nedam Ned Vev N1 N2 3 NE 201                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | ONN             | 1070  |
|           | د د ۱       | URL: UNTERT URBUD ERTITES URLUE, NERONANTUTERETATIONE ET MITES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | CNN             | 4000  |
|           |             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | ONN             | 5030  |
|           |             | ELTER CONTRACT ANALYS STRUCT DALLER NEROM NTO REV NUND OFFICIAL OF                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | ONN             | 4100  |
|           | 1.5         | UNDER DATEAL GROUD, DR. TALE GALDE, NERGIN, N. D. REALAT, WE AR 12, 0, 00)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | MBD             | 4110  |
|           |             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | OMM             | 4120  |
|           |             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | ONN             | 4130  |
|           |             | 199 1990 - SUSHERSUN<br>Deserver offen anderes duarents formetes underes Notionals                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | HIHI<br>ONN     | 1110  |
|           | 149         | NALIDI CONTRADI UPINICTI (NUMBETCI) (NETOCI) (NETACI) (NETACI)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | HEIN .          | 4100  |
|           |             | Electric Condensity (Condensity)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | - FIFIN         | 4160  |
|           |             | になって、「あったはと、わんりにからかり」                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | THE P           | -4170 |
|           |             | LALIE AND ADDRESS AND ADDRESS AND ADDRESS ADDRES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | - FIFIN         | 4180  |
|           |             | [H] 1-77 点开去不能说出!                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | FILT            | 4150  |
|           | 140         | 12717 (S.P.5) (S.P.C.) (S.P.C.) (S.P.C.) (S.P.C.)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | REAL            | -4200 |

|            |      | IF (F5.NE.1) GO TO 14S                                                              | AMN             | 4210          |
|------------|------|-------------------------------------------------------------------------------------|-----------------|---------------|
|            |      | MXINC=0                                                                             | F.M.L           | 4220          |
|            | 100  | DU 144 ISLINFREU<br>MYINC-MAYD(MYINC.NSTPS(I))                                      | Cotty.          | 4250          |
|            | 144  | WRITE (6,203) INTYP, MXINC                                                          | AMN             | 4250          |
|            | 145  | IF (MX.NE.1) GO TO 154                                                              | FIMN            | 4280          |
| С          |      |                                                                                     | 62221           | 4270          |
| <b>C</b> * | **** | * READ AND WRITE SECOND-GENERATOR INFORMATION                                       | F.M.N.          | 4230          |
| Ľ          |      |                                                                                     | Eddil.          | 4250          |
|            |      | READ (5,248) N1,N2,NT,ZS1,AMP(NERED), FRED(NERED), PHASE(NERED)                     | 6M01            | 4310          |
|            |      | IF ((NT.EO.R), OR. (NT.EO.G)) GO TO 148                                             | 6.MM            | 4320          |
|            |      | IF (NT.EO.C) GO TO 150                                                              | fann i          | 4330          |
|            |      | CALL CXTERT (NADD, BR, TYPE, VALUE, NEROM, NTO, KEY, N1, N2, S, NT, ZS1)            | FWN.            | 4340          |
|            |      |                                                                                     | FIGUL<br>OMDE   | 4000          |
|            |      | GO TO 152                                                                           | 6MM             | 4370          |
|            | 148  | CALL CXTPRT (NADD, BR, TYPE, VALUE, NFROM, NTO, KEY, N1, N2, 5, NT, 251)            | <b>FINIS</b>    | 4380          |
|            |      | NRES=NRES+1                                                                         | F.M.            | 4330          |
|            |      | NZT1=1                                                                              | FMN.            | 4400          |
|            | 150  | GUTU 152<br>CALL EVERT (NATH, RR. 7985, HALLE, NEROM, NTG, KEY, NI, NR. 2, NT, 751) | F. HY           | 4410<br>22⊃n  |
|            | 100  | NCAP=NCAP+)                                                                         | ENN.            | 4430          |
|            |      | NZT1=2                                                                              | F.MAN           | 4440          |
|            | 152  | CALL CXTPRT (NADD, BR, TYPE, VALUE, NFROM, NTO, KEY, N1, N2, 35, IS, 0.0)           | Failth          | 4430          |
|            |      | NCS=NCS+1                                                                           | ENN.            | 4430          |
|            |      | $WR(1E_{0}, 242) N1, N2, 251, N1$                                                   | Falañ -         | 4470          |
|            |      | WRITE (6,246) NEREO, FRED(NEREO), AMP(NERED), PHASE(NERED)                          | E MAR           | 4450          |
| С          |      |                                                                                     | ente:           | 4500          |
| C*         | **** | FORM THE APPROPRIATE AUGMENTED LINEAR NETWORX                                       | e an            | 4510          |
| С          |      |                                                                                     | ENG!            | 4520          |
|            | 154  |                                                                                     | ENN:            | 4320          |
|            |      | N=NLBN(K)                                                                           | 6.TN            | 4550          |
|            |      | ICON=ICONT(N)                                                                       | 62221           | 4550          |
|            |      | JCON=JCONT(K)                                                                       | 6.m             | 4570          |
|            |      | NNODE=MAXO(NNODE,NFROM(N),NTO(N))                                                   | FORM .          | 4580          |
|            |      |                                                                                     | EDD1            | 4350          |
|            |      | CALL CAGMNT (K, N, KEYU, NADD, ICON, JCON, NCT, BR, NFROM, NTO, TYPE, ICON          | IANN            | 4310          |
|            | 1    | I T, VALUE, KEY)                                                                    | finn.           | 4930          |
|            | 156  | CONTINUE                                                                            | <u>FUNN</u>     | 4330          |
|            |      | IF (MX.NE.1) GO TO 158                                                              | FRRI.           | 4340          |
|            |      |                                                                                     | CMN.            | 4530          |
|            | 158  | NELEM=NADD                                                                          | 6.222           | 4970          |
| С          |      |                                                                                     | enni.           | 4980          |
| C*         | ***  | SORT ELEMENT DATA                                                                   | AWN             | 4520          |
| С          |      |                                                                                     | EPD1            | 4700          |
|            |      | NILSANDS<br>CALL CODIT (NELEM. RR. NEROM. NTO, TYPE, TOONT, NALVE, YEY)             | COTT            | 6720          |
| C          |      |                                                                                     | 6331            | 4730          |
| Č*         | ***  | * COMBINE PORTS WHICH APPEAR ACROSS SAME NODE PAIR                                  | ALCN:           | 4740          |
| С          |      |                                                                                     | 6531            | 4750          |
| c          |      | CALL URDERT (MELEM, BR, NERUM, NID, KEY, TYPE, URLUE, ICUNI)                        | 6.00            | -9760<br>2770 |
| с<br>г¥    | ***  | * CONSECUTIVELY NUMBER THE EXTRACTED VINGEPENDENT PORTS                             | Fa a l          | 4720          |
| č          |      |                                                                                     | 6.111)<br>6.111 | 4700          |
|            |      | ///                                                                                 |                 |               |

|        | IF (NCONT(I).ED.I) GO TO 163                                      | AMN 4318   |
|--------|-------------------------------------------------------------------|------------|
|        | 1.44天中1.                                                          | AMN 4820   |
| 150    | TE (PODNT(1) GT. I) GT. 162                                       | 6MN 4830   |
| 100    |                                                                   | CMN 4940   |
|        | 1. (3.20.MIC3) 60 10 163                                          | niii 4040  |
|        | 17 J * 1                                                          | 6791 4850  |
|        | 80 70 190                                                         | AMN 4860   |
| 100    | DO 154 KaliNTCS                                                   | 6MN 4870   |
| 104    | T = (NEDNECC) = 0 NEDNECC) = 1                                    | 6MN 4881   |
| 107    |                                                                   | CMN 4000   |
| _ 100  |                                                                   | Filli 4030 |
| C      |                                                                   | FITT 490(  |
| Caaac  | * REMUMDER THE CONTROLLING PORTS FOR THE MONLINEAR ELEMENTS       | AMN 4910   |
| Ceese  | * AND ASSIGN MUMERICAL (DENTIFIER(JODNI( )) WITH EACH NONLINEAR   | AMN 4920   |
| 10444  | * FLENENT TYPE                                                    | AMN 4930   |
| 6      |                                                                   | OMN ADAL   |
| L      |                                                                   |            |
|        | D0_165_R=1,11,05                                                  | Finit 4550 |
| 153    | NEDI(K)=NODI((K)                                                  | AMN 4550   |
|        |                                                                   | AMN 497(   |
|        | .12=80.07                                                         | AMN 4980   |
|        | 20 100 K-1. NNT 5M                                                | 6MN 4990   |
|        |                                                                   | 0MN 5000   |
|        |                                                                   |            |
|        | J1J3+1                                                            | AMN 2010   |
|        | . <u></u>                                                         | AMN 5020   |
|        | 19-2-2-41                                                         | AMN 5030   |
|        | TE (PTYPE(Y) ED N3) CD TO 174                                     | 6MN 5046   |
|        |                                                                   | 0MN 5050   |
|        |                                                                   | AMN COD    |
|        | TE (TINETCO)STRUCT PO TO INS                                      | HAN 3060   |
|        | IF (WTYPE(K).E0.MD) GO TO 173                                     | AMN 5070   |
| 170    | 200NT(K)=1                                                        | AMN 5080   |
|        | 60 TO 175                                                         | AMN 5090   |
| 170    |                                                                   | 6MN 5100   |
| 110    |                                                                   | 0'M 5110   |
|        | 60 10 176                                                         | AMN CIO    |
| 174    |                                                                   | HIN 5120   |
| 176    | NEDUN=NLBN(K1)                                                    | AMN 5130   |
|        | NCBNT(J1)=NCBUM                                                   | AMN 5140   |
|        | MERUT (JP) = MERUN                                                | AMN 5150   |
|        |                                                                   | AMN 5160   |
|        |                                                                   | OMN 5170   |
|        | 60 10 130                                                         | ANNI CLOC  |
| 173    | NCON (CROFFICERICKI)                                              | ANN 5180   |
|        |                                                                   | AMN 5198   |
|        | K1=K1+Q                                                           | AMN 5200   |
|        | (1,0,0,0,0,0) = 0 (N(X1))                                         | AMN 5210   |
|        |                                                                   | AMN 5220   |
|        |                                                                   | 0MN 5220   |
| 16.1   |                                                                   |            |
|        | 17 (NK.NE.1) 60 70 182                                            | BUN 254    |
|        | LOERGANCUTANNELEMANNELEMANNELEMA1                                 | ANN 5250   |
|        | NOBHT (LOSRO) = NLEN(NICS)                                        | AMN 5260   |
| 120    | - HSCINNCAP+HIND                                                  | EMN 5270   |
| 202    |                                                                   | AMN 5230   |
| _      | NER-GELEU                                                         | ANN EDD    |
| C      |                                                                   | 500 DCD    |
| ()៖៩៩៩ | *PRINT AUGMENTED LINEAR NETRORK DESCRIPTION                       | FUN 2300   |
| C      |                                                                   | ANN 5310   |
|        | 1277E (6,254)                                                     | AMN 5321   |
|        | LIDITE (AS DED)                                                   | 6NN 5336   |
|        |                                                                   | ONN 524    |
|        |                                                                   |            |
|        | Ed. 2009 (1997) Solida                                            | First 200  |
| 124    | URITE (6.225) BRCK)-MEROM(K), NTD(K), TYPE(K), VALUE(K), ICONT(K) | FIN 535    |
| C      |                                                                   | AMN 5370   |
| 12232  | URITE EXTRACTED PORT THEORNITION                                  | 6111 528   |
| C      |                                                                   | AMN 539    |
| 5      |                                                                   | 6MN 540    |
|        | 秋雨 エレス へのすね こうえ                                                   | CLU1 2401  |

NDUMENDR-NEG DO 1900 Tel-MOS HERRY (20) eT HAUNARDUNEL URRIE (3)0700 MPORT(1), MERCM(NDUM), NTO (MPUM) 185 CONTINUE С ZERO CUT O HATRIS 044004 C EO 103 I=1,1000EE DO 100 J=1,1000EE 103 A(I=5)=0 С STORE ENTRIES INTO A MATRIX []\*\*\*\*\* ē 20 100 K=1+MELEN FACH=1FRC11(K) TC=1070(K) DF UVRC11 MELOD A(FRCM-K)=1 IF (TC=10500 A(FRCM-K)=1 199 CONTRIPE 17 (DD.(15.1) 60 TO 194 С ្រឹងងងងង FREHT THE A MATRIX FOR DEBUG RUN ē HRITE (6.878) 80 182 1=1,00085 192 MRITE (6,274) (6(1,J),J=1,NBR) ••• С Nassaa FORMULATE HYDRID EQUATIONS C 104 CALL PHYERD (NORABHOTE, DD. NPORTIAMNEODL, TIADR, TYPE, ICONT, VALUE, A, 18ADER, AND, EXTREMENTED (NAMODE, NACR) C  $(i,j) \in \mathcal{I}$ \*\* FORMULATE STATE SQUATIONS
DALL STATE (NFDRT1.ANSDDL, II.NER.NSTU, SE, AMAT, DMAT, DMAT, EMAT, WALLUNG
12.AMS.HUER.NKSTU, MKRRT)
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|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|--------------------------|
| Sec.          | CONTRACTOR CHERTER AT TRACTED                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | ·/····         | 0000                     |
|               | الهوينانية بالاستراب المحتم                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1              | 0000                     |
| .,            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1.1            | 1.5 4.01                 |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1. S.          | - (- (- <del>-</del> - ( |
|               | UK (WANIS) OF TO YOR                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1              | $\sim 10$                |
| 0             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | C              | 0.20                     |
| 100000        | كمالك المحالي ا                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 100            | 6.52.0                   |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1.1.1          | 1                        |
| •             | No. 1. The second se                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1              |                          |
| •             | na 💷 Andre State (State Charles and State Charles 🖾 dal)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 1              | 6111                     |
| 1             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | (              | 01.00                    |
|               | TO TERRETE A VIEWER AT STREET REPORTED THE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 1.1.1          | -6.130                   |
| 2             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1000           | C121                     |
| 1.7 3         | CONTROLOGIC CONTROLOGIC CONTROLS FUELD, MATERIAN, MATERIAN, MATERIAN, MATERIAN, MATERIAN, MATERIAN, MATERIAN, M                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1.11           | 6120                     |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 7              | 0120                     |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                | 0.10                     |
| · •           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1              | 0100                     |
| ngan sa sa sa | [1] A. Serreration and A. Kamarana and A. Shina and A<br>Shina and A. Shina and A. | First          | 문문문민                     |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0              | 6159                     |
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| •             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | CD             | 61100                    |
| :             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | · · · ·        | 1150                     |
| lanne.        | na n                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 1000           |                          |
|               | and the second                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1              | 0100                     |
| ·             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1              | 0 1 J                    |
|               | 1. The second                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1.1.1          | CECU.                    |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1.121          | $C \ge 0$                |
| 2             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 6211           | 61250                    |
| tjaares       | - TATUY MURUTU SARAN UDAAREE MUSICIAA AND RESPONSES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1111           | 01.73                    |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 10000          | 0570                     |
|               | and the second                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1.00           | 0100                     |
|               | A set of the set of   | 1              | 0.000                    |
|               | n an                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | to o i         | 0110                     |
| -             | الرافية كماميده والمرائب والمرافق وفينا فرنسا فالمراكب المتحادين فالمتمان مخط كالمتماد المراكبة فالمتارين المرا                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | E. e.i         | 62.30                    |
| -             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1.1.1.1        | $\{1, 1, 0\}$            |
| i ja sisis a  | CONTAIND THE DONALEUE CONTRUL CEREDINARY CONSTRUCTINE MARIPUS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 1.11           | -21 E.a.                 |
| 1.23.3        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | (131           | 6110                     |
| n) –          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 6231           | Charles I                |
|               | 17 - 17 - 17 - 17 - 17 - 17 - 17 - 17 -                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1.1.1.1        | 05.50                    |
|               | אין אין אין אין אין אין אין איז                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1.1.1          | 1100                     |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <i></i>        | ຮູ້ຮູ້ແລ                 |
| •             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 2.5.1          | 01.70                    |
| •             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1              | 0220                     |
|               | n a se internet de la contra de l                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | i              | 1220                     |
| -             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1.0.01         | 6.0                      |
| 1221          | n e de la constante de la const                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | (111)          | 0410                     |
|               | 17 (1111) (0.17) (0.10) (202)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 6.11           | 6429                     |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | GUI            | $C \cong 0$              |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                | 1-2-0                    |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                | 5                        |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1.1.1.1        |                          |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | E. at l        | 1.0.51                   |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1.00           | 54. O                    |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1              | 0.000                    |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1254           | 1.4770                   |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1.11           | 6.2.3                    |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                | - i o                    |
| ~~            | ·                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 2000<br>2000   | 5 50                     |
| *             | The second se                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1.2.2          |                          |
| · ·           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1 21           | 2.1.1                    |
| · •           | STATES STATES STATES AND A SAME AND AN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | $\epsilon = 0$ | 19                       |
| •             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | . :            | . I                      |
| 110           | 2011))) - 112 - 212 - 212 - 210 P - 2 1 P - 2 1 P - 2 2 2 3 7 1 - 40X - 0212 02120 1 - 1 1 - 2 1 - 1 - 2 1 - 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                | . 19                     |
| •             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ٠,             | $\gamma = -10$           |
| • • • •       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 11             | - 1                      |
|               | and the second                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                | 1                        |
|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                |                          |

218 FORMAT (//,1%,15HLINEAR ELEMENTS) AMN ES10 220 FORMAT (1M0,6HBRANCH,4%,4HFROM,3%,2HTO,5%,7HELEMENT,3%,7HELEMENT,36%) CS20 1%,7HCONTROL,7,1%,6HNUMBER,4%,4HNODE,2%,4HNODE,5%,4HTYPE,5%,5HVALUEARN 6S30 2,4%,6HBRANCH) CMC EC10 CMC EC10 2,4%,6HBRANCH) CC20 AMU 2030 1.)) ADDI ESTO 224 FORMAT (212,11,2A3) ritti espo 226 FORMAT (313, A2, E10, 3, I3, I1, A1) 223 FORMAT (2X, I3, 6X, I3, 0X, I3, 7X, 62, 4X, 10, 3, 3X, I3) 230 FORMAT (2X, I3, 5X, I3, 3X, I3, 7X, 62, 4X, 10, 3) ATTI CSSO ATTI CSSO ATTI C700 232 FORMAT (213,A2,213) 234 FORMAT (211,A2,213) 235 FORMAT (211,3) 235 FORMAT (211,3) ALT: ETTO ALT: ETTO ALT: ETTO ALT: ETTO ALT: ETTO ALT: ETTO 235 FORMAT (210,37,210,37) 238 FORMAT (213,42,510,3) 240 FORMAT (7,17,18,1983297CE INFORMATION:) 62111 6700 6221 6700 242 FORMAT (1H0, MARRON, 2X, 13, 2X, 2HTO, 2X, 13, 5X, SHIMPEDANCE, 2X, E10.3, 3X, ( 1A2) 244 FORMAT (JH0, SHEREOUENCY, 5X, SHUALUE(, A3, 1H), 5X, SHAMPLITUDE, 4X, 10HPLAUE 60:00 244 FORMAT (1M0, SHERECUENCY, 5X, 5HUALUE(.A3, 1H), 9X, 9HAMPLITUDE, 4X, 10HPU201 (120) 1ASE(DEG), Z1H, 9(1H,), 5X, 10(1H,), 9X, 9(1H,), 4X, 10(1H,)) (AD) (20) 24S FORMAT (1H, +7, 15, 30, 210, 3, 0X, 210, 3, 2X, 210, 3) (AD) (20) 248 FORMAT (213, A2, 4210, 3) (AD) (20) 250 FORMAT (4210, 3, 12) (AD) (20) 252 FORMAT (4210, 3, 12) (AD) (20) 252 FORMAT (4210, 3, 12) (AD) (20) 254 FORMAT (1M0, 2X, 40, FOM, 5X, 2HTO, 5X, 4HTYPE, 4X, 7HCONTROL, 5X, 22HPOLYMOMXAD) (20) 11AL COEFFICIENTS, Z1H, 2X, 44HDOBE, 4X, 4HNODE, 11M, 3M(1), 5X, 2HC2), Z1H, 4AC( ES0) 22M, 4(1H, ), 4X, 4(1H, ), 3X, 4(1H, ), 2X, 11(1H, ), 3X, 23(1H, )) (AD) (20) 256 FORMAT (2H0, 7Y, 12, 5Y, 12, 2Y, 0P, 15Y, 2H2)=, 512, 4, 3Y, 3M(2), Z1H, 4, 3Y, 3M(2)) (CD) 4200 00000 4200 0000 4200 0000 4200 0000 4200 0000 256 FORMAT (1M0, 3%, 12, 6%, 12, 7%, 62, 16%, 3HA1=, 512, 4, 3%, 3HA2=, 512, 4, 3%, 3HA 103=, E12.4) 103-, 112-, 77 253 FORMAT (1M , 38X, 4HA02=, 512.4, 2K, 4HA11=, 512.4, 2X, 4HA30=, 512.4) (1) 260 FORMAT (1M , 28X, 4HA03=, 512.4, 2X, 4HA21=, 512.4, 2X, 4HA12=, 512.4) (2) 262 FORMAT (1M0, 3X, 12, 6X, 12, 7X, A2, 3X, 12, 5X, 12, 3X, 4HA10=, 512.4, 2X, 4HA01) (1) 1=, 512.4, 2X, 4HA20=, 512.4) (1) 69.10 4101 ESPA 
 254
 FORMAT (////,1X,35HAUGMENTED LINEAR NETWORK DESCRIPTION)
 6001 05:20

 255
 FORMAT (2X,13,6X,13,3X,13,7X,02,4X,510.3,3X,13,5X)
 6001 05:40

 253
 FORMAT (1H0,17HPORT\_OSSIGNMENTS:,/1H0,4X,4HPORT,4X,5HNODE PAIR,/1HAUD 05:50
 1 ,3X,6HNUMBER,3X,4HFROM,2X,2HTO,/1H ,3X,5(1H.),3X,4(1H.),1X,4(1H.)(21 620 2) 2) ATT 6550 ATT 6550 270 FORMAT (6X,12,5X,12,3X,12) 272 FORMAT (///,9H & MATR1X) 6504 7060 6504 7010 6101 7010 274 FORMAT (110,4013) 276 FORMAT (/, 12H EIGENVALUES) 278 FORMAT (/,2(3X,E12,4)) 280 FORMAT (/, 13H MODAL MATRIX) £111 d, di 282 FORMAT (14,4(2%,512.3,3%,512.3)) 284 FORMAT (1H0,25HTINE FOR FORMING ZOC(SEC),F10.4) 285 FORMAT (1H ,39HTINE FOR OBTAINING OUTPUT SPECTPUM(SEC),F10.4) 283 FORMAT (1H ,25HTOTAL EXECUTION TIME(SEC),F10.4) CC170.406001 7600 6701 7600 CONTERPO С **CHD** SUDROUTINE DOPTNS (TITLE, D3, F5, NK, SE, NM, PR, PC, AP) С :÷0 r 110\*\*\*\*;"(), \*167 \*1777 10 С 4 THIS CUD-PROGRAM REPFORMS THE FOLLOWING FUNCTION: () 1. SET THE FLOS UMPIRIDES FOR THE USER REQUESTED OPTIONS. () AND ALSO PRINT THESE OPTIDUS. () 1.0 C## \*\*\*\* COL ε ÷0 С  $r \in \mathbf{I}$ Ĉ \* THIS SUD-FROGRAMMS GLOSSARY OF FORTRAL MAMES: 1.9**[**#### 5 28 DD : FLOS WARTED CETTOLS DD : FLOS WARTEDLE FOR DEDUS DUN · .... С # 1.10 C

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FLAG VARIABLE FOR FREQUENCY SWEEP FLAG VARIABLE FOR TWO INPUT SOURCES FLAG VARIABLE FOR STATE EQUATION PRINT-OUT FLAG VARIABLE FOR SIGENVALUE-EIGENVECTOR INFORMATION PRINT-OUT FLAG VARIABLE FOR POLE-RESIDUE INFORMATION OF ZOO PRINT-OUT FLAG VARIABLE FOR COMPLETE SPECTRUM PRINT AND PLOT FS \*B02 3 : 120 ÷ tεk 2 \*E02 130 ΞΞ e, 2 \* DOP 140 0 N11 \*BOP 150 . \* EOP 160 FR \*CO2  $\langle 2$ 2 170 4 \*EOS 180 FC : \*D02 190 12 \*EOP 200 62 : FLAG VARIABLE FOR VALLY PORT PRINT-OUT 0 \*DOP 210 ö \* EOP 220 230 \*EOP С EOP 240 INDEGER TITLE(1), DD, FS, SE, PR, PC, AP, LANS(2) EDP 250 BATA LAMS(1), LANS(2)/2MVES, 3H NO/ ECP 250 С EO? 270 C\*\*\*\*\* INIVIALIZE OPTION CONTROLLING FLAG VARIABLES DOP 230 ē EOP 290 EGP 300 E0P 310 EOP 350 EOP 330 EOP 340 EOP 350 EOP 360 DOP 370 С 203 380 CARANA RESET FLAS VARIABLE VALUES FOR THE REQUESTED OPTIONS EOP 390 С 200 400 DO 130 I=1.0 EDP 410 ICO 1410 IPUM-TITLE(I) IF (IPUN.E0.2M ) 60 TO 122 IF (IPUN.E0.2MDB) 60 TO 102 EOP 420 507 430 ECP 440 60 70 104 EOS 450 102 <u>6];=1</u> EGP 460 60 70 100 17 (IDUM.EQ.EMFS) 60 70 105 COP 470 104 ECP 480 00 70 103 EOP 490 7S=1 103 COP 500 00 70 130 EOP 51017 (IBUILEO.2KMX) GO TO 110 103 EOP 520 60 70 112 530 EOP 110 1:::=1 EOP 540 60 70 120 EOP 550 112 (IDUN.E0.2KSE) 60 TO 114 77 EGP 560 CO TO 116 LOP 570114 C 7:1 EOP 580 00 70 120 77 (IDUN E0.2KNM) 60 70 113 EOP 580 115 PCS 600 60 10 120 EOP G10 113 111=1 EOP 650 60 78 120 DO5 630 (IBUN. 20.2KPR) 60 70 122 120 IF1-OP 640 101 101 124 EOP 650 HO IO 120 FRAT FRATO 120 FRATO 120 ER (1889129-2820) 60 70 123 EQ TO 120 122 TOP 660 DOP 670 124 EDP 030 DOP 630 Post FOP 700 710 123 co to 150 DOP

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| _                | 128 IF (IDUM.EO.2HAP) AP=1<br>130 CONTINUE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          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| С<br>Ся          | ***** PRINT THE OPTIONS LIST                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        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|                  | 134 FORMAT (1H0,23HUSER REQUESTED OPTIONS:)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         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|                  | 135 FORMAT (1H +2X,150DEBUG PRINT-OUT:+1X,A3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       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|                  | 133 FORMAT (IN ,2X,270FREDUENCY SMEEP CAPABILITY:,1X,A3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            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|                  | 140 FURNAL (TH +2% ISANUS-INFO) CIRCULA, 12(A3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     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|                  | 142 FUKAHI UTH JENJERSIMAL EUUHITAA KATHIFUTIKI AKAJA<br>144 FURMAT (14 - AKAJATIKA KATHIKA MARAKA MARAKA AKAJA (14 - AKAJA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         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|                  | 144 FURTHET (11 - 22.3) SCHEIGENOHLUES HOUSE HARRINGEN HAUFT FURTHET IN HES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         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|                  | 148 FORMAT (1H - 2X. 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|                  | 150 FORMAT (1H .2X.27HALL EXTRACTED PORT OUTPUTS: 1X.A3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            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|                  | SUBROUTINE CAGMAT (K,N,NKEY,NADD,ICON,JCON,NCT,BR,NFROM,NTO,TYPE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    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| Č*               | ****** THIS SUB-PROGRAM PERFORMS THE FOLLOWING FUNCTION:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            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|                  | ****** THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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                                                                                                                                                                                                                   | 20<br>160<br>110<br>120                                                             |
|                  | ****** THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:<br>* 1. CXTPRT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   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                                                                                                                               | 03<br>601<br>011<br>120<br>120                                                      |
|                  | ****** THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:<br>* 1. CXTPRT<br>*<br>****** THIS SUB-FROGRAM#S GLOSSARY OF FORTRAN NAMES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | *06.5<br>*065<br>*065<br>*065<br>*065<br>*065                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 20<br>100<br>110<br>120<br>130<br>130                                               |
|                  | ****** THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:<br>* 1. CXTPRT<br>*<br>****** THIS SUB-FROGRAM#S GLOSSARY OF FORTRAN NAMES:<br>* K : NUMBER OF THE NONLINEAR ELEMENT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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                                                                                                                               | 50<br>165<br>110<br>120<br>130<br>140<br>150                                        |
|                  | ****** THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:<br>* 1. CXTPRT<br>****** THIS SUB-FROGRAM#S GLOSSARY OF FORTRAN NAMES:<br>* K : NUMBER OF THE NONLINEAR ELEMENT<br>* N : USER SPECIFIED BRANCH NUMBER FOR THE K-TH                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | * DRG<br>* DAG<br>* DAG<br>* DAG<br>* DAG<br>* DAG<br>* DAG<br>* DAG<br>* CAG<br>* CAG                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 50<br>163<br>110<br>120<br>130<br>140<br>150<br>150                                 |
|                  | ******* THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:<br>* 1. CXTPRT<br>****** THIS SUB-FROGRAM#S GLOGSARY OF FORTRAN NAMES:<br>* K : NUMBER OF THE MONLINEAR ELEMENT<br>* N : USER SPECIFIED BRANCH MUMDER FOR THE K-TH<br>* MONLINEAR ELEMENT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | * DEG<br>* DEG | 50<br>100<br>120<br>120<br>120<br>120<br>120<br>120<br>120<br>120                   |
|                  | ****** THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:<br>* 1. CXTPRT<br>****** THIS SUB-FROGRAM#S GLOSSARY OF FORTRAN NAMES:<br>* K : NUMBER OF THE NOMLINEAR ELEMENT<br>* N : USER SPECIFIED BRANCH NUMBER FOR THE K-TH<br>* NET : KEY UALUE FOR THE NOMLINEAR ELEMENT PORT DRAT<br>* NET : KEY UALUE FOR THE NOMLINEAR ELEMENT PORT DRAT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | * DEG<br>*                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 500<br>100<br>1100<br>1200<br>1200<br>1200<br>1200<br>1200<br>12                    |
|                  | ****** THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:<br>* I. CXTPRT<br>****** THIS SUB-FROGRAM#S GLOSSARY OF FORTRAN NAMES:<br>* K : NUMBER OF THE NOWLINEAR ELEMENT<br>* N : USER SPECIFIED DRANCH NUMBER FOR THE K-TH<br>NOMLINEAR ELEMENT<br>* NKEY : KEY UALUE FOR THE NOMLINEAR ELEMENT PORT DRAM<br>* NADD : CURRENT HIGHEST DRANCH NUMBER IN THE LINEAR                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        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| าตูกกลูกกลูกกลูก | ****** THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:<br>1. CXTPRT<br>****** THIS SUB-FROGRAM#S GLOSSARY OF FORTRAN NAMES:<br>K : NUMBER OF THE NOMLINEAR ELEMENT<br>N : USER SPECIFIED DRANCH MUMDER FOR THE K-TH<br>NOMLINEAR ELEMENT<br>NEY : KEY UALUE FOR THE NOMLINEAR ELEMENT PORT DRAN<br>NADD : CURRENT HIGHEST DRANCH NUMBER IN THE LINEAR<br>METMORY<br>* USER SPECIFIED REALCONTROL INC. BEAUCH NO                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | * DR/4<br>* DAG<br>* DAGG<br>* DAG<br>* DAG                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 100<br>100<br>120<br>120<br>120<br>120<br>120<br>120<br>120<br>120                  |
| าตุกอนกุกกระการ  | ****** THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:<br>1. CXTPRT<br>****** THIS SUB-FROGRAM#S GLOSSARY OF FORTRAN NAMES:<br>K : NUMBER OF THE MOMLINEAR ELEMENT<br>N : USER SPECIFIED DRANCH NUMBER FOR THE K-TH<br>NONLINEAR ELEMENT<br>NKEY : KEY UALUE FOR THE NOMLINEAR ELEMENT PORT DRAN<br>NADD : CURRENT HIGHEST DRANCH NUMBER IN THE LINEAR<br>NETWORK<br>ICON : NOWLINEAR ELEMENT FIRST-CONTROLLING DRANCH NO                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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                                                                                                                                 | 500<br>1000<br>1200<br>1200<br>1200<br>1200<br>1200<br>1200<br>1                    |
| าลูกกลูกกรรรรร   | ****** THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:<br>1. CXTPRT<br>THIS SUB-FROGRAM#S GLOSSARY OF FORTRAN NAMES:<br>K : NUMBER OF THE NOWLINEAR ELEMENT<br>N : USER SPECIFIED DRANCH NUMBER FOR THE K-TH<br>NOMLINEAR ELEMENT<br>NKEY : KEY UALUE FOR THE NOWLINEAR ELEMENT PORT DRAN<br>NADD : CURRENT HIGHEST DRANCH NUMBER IN THE LINEAR<br>HETMORK<br>ICON : NOWLINEAR ELEMENT FIRST-CONTROLLING DRANCH NO<br>JCON : NOWLINEAR ELEMENT FIRST-CONTROLLING DRANCH NO                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            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|                  | <pre>THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:     1. CXTPRT     THIS SUB-FROGRAM#S GLOSSARY OF FORTRAN NAMES:     K : NUMBER OF THE NOWLINEAR ELEMENT     N : USER SPECIFIED DRANCH NUMBER FOR THE K-TH     NOMLINEAR ELEMENT     NKEY : KEY UALUE FOR THE NOMLINEAR ELEMENT PORT DRAM     NADD : CURRENT HIGHEST DRANCH NUMBER IN THE LINEAR     HOTMINEAR ELEMENT FIRST-CONTROLLING DRANCH NU     JOON : NOWLINEAR ELEMENT FIRST-CONTROLLING DRANCH NU     JOON : NOWLINEAR ELEMENT FIRST-CONTROLLING DRANCH NU     ACON : NOWLINEAR ELEMENT FIRST NUMBER     ARRAY NAMES OS DEFINED IN DUB-PROGRAM ANAIH     ACON : NOWLINEAR ANAIH     ACON ANAIH</pre>                                                                           | *0:/4<br>*0:05<br>*0:05<br>*0:05<br>*0:05<br>*0:05<br>*0:05<br>*0:05<br>*0:05<br>*0:05<br>*0:05<br>*0:05<br>*0:05<br>*0:05<br>*0:05<br>*0:05<br>*0:05                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 1000<br>1100<br>1200<br>1200<br>1200<br>1200<br>1200<br>1200                        |
|                  | <pre>THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:     I. CXTPRT THIS SUB-FROGRAM#S GLOSSARY OF FORTRAN NAMES:     K : NUMBER OF THE NOWLINEAR ELEMENT     N : USER SPECIFIED DRANCH NUMBER FOR THE K-TH     NOMLINEAR ELEMENT     NKEY : KEY UALUE FOR THE NOMLINEAR ELEMENT PORT DRAM     NADD : CURRENT HIGHEST DRANCH NUMBER IN THE LINEAR     HETWORK     ICON : NOWLINEAR ELEMENT FIRST-CONTROLLING DRANCH NU     JOON : NOWLINEAR ELEMENT FIRST-CONTROLLING DRANCH NU     NOT : CURRENT NOMLINEAR ELEMENT PORT NUMBER     ARRAY NAMES OF DEFINED IN SUB-PROGRAM AMAIN </pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <ul> <li>A 10 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 -</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1000<br>1100<br>1200<br>1200<br>1200<br>1200<br>1200<br>1200                        |
|                  | THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:<br>1. CXTPRT<br>THIS SUB-FROGRAM#S GLOSSARY OF FORTRAN NAMES:<br>K : NUMBER OF THE NOWLINEAR ELEMENT<br>N : USER SPECIFIED DRANCH NUMBER FOR THE K-TH<br>NOWLINEAR ELEMENT<br>NKEY : KEY UALUE FOR THE NOWLINEAR ELEMENT PORT DRAN<br>NADD : CURRENT HIGHEST DRANCH NUMBER IN THE LINEAR<br>NETWORK<br>ICON : NOWLINEAR ELEMENT FIRST-CONTROLLING DRANCH NO<br>UCON : NOWLINEAR ELEMENT FIRST-CONTROLLING DRANCH NO<br>UCON : NOWLINEAR ELEMENT FIRST-CONTROLLING DRANCH NO<br>UCON : CURRENT NOWLINEAR ELEMENT PORT NUMBER<br>ARRAY NAMES OF DEFILED IN CUB-PROGRAM AMAIN                                                                                                                                                                                                                                                                                                                                                                                                                                                                     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|                  | THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:<br>1. CXTPRT<br>THIS SUB-FROGRAM#S GLOSSARY OF FORTRAN NAMES:<br>K : NUMBER OF THE NOWLINEAR ELEMENT<br>N : USER SPECIFIED DRANCH NUMBER FOR THE K-TH<br>NOWLINEAR ELEMENT<br>NKEY : KEY UALUE FOR THE NOWLINEAR ELEMENT PORT DRAN<br>NADD : CURRENT HIGHEST DRANCH NUMBER IN THE LINEAR<br>HETNORK<br>ICON : NOWLINEAR ELEMENT FIRST-CONTROLLING DRANCH NO<br>UCON : NOWLINEAR ELEMENT FIRST-CONTROLLING DRANCH NO<br>UCON : NOWLINEAR ELEMENT FIRST-CONTROLLING DRANCH NO<br>CORENT NOWLINEAR ELEMENT FIRST-CONTROLLING DRANCH NO<br>CORENT NOWLINEAR ELEMENT FIRST-CONTROLLING DRANCH NO<br>CON : NOWLINEAR ELEMENT SECOND-CONTROLLING DRANCH NO<br>CON : NOULTINEAR ELEMENT SECOND-CONTROLLING DRANCH NO<br>CON : NO CON : NO CONTROL NO CONTROLLING DRANCH NO<br>CON : CON : NO CON : NO CON SECOND-CONTROLLING DRANCH NO<br>CON : NO CON : NO CON SECOND -CONTROLLING DRANCH NO<br>CON : NO CON : NO CON SECOND -CONTROLLING DRA | ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>ALASS<br>AL                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 10000000000000000000000000000000000000                                              |
|                  | <pre>THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          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                                                                                                                                                                                                                                                                                                                                                 | 10000000000000000000000000000000000000                                              |
|                  | <pre>THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:<br/>I. CXTPRT THIS SUB-FROGRAM#S GLOSSARY OF FORTRAN NAMES:<br/>K : NUMBER OF THE NONLINEAR ELEMENT<br/>N : USER SPECIFIED DRANCH NUMBER FOR THE K-TH<br/>NONLINEAR ELEMENT<br/>NEY : KEY UALUE FOR THE NONLINEAR ELEMENT PORT DRAN<br/>NADD : CURRENT HIGHEST DRANCH NUMDER IN THE LINEAR<br/>HETNORK<br/>ICON : NONLINEAR ELEMENT FIRST-CONTROLLING DRANCH NO<br/>UCON : NONLINEAR ELEMENT FIRST-CONTROLLING DRANCH NO<br/>NOT : CURRENT NONLINEAR ELEMENT PORT NUMBER<br/>ARRAY NAMES OF DEFIDED IN SUB-PROGRAM AMAIN<br/>INTEGER FR.TYPE.C.L.S.R.G.UM.MC.CV.CC<br/>DIMENSION DRACH, NERGH(1), NERGIGI), NERGIGI), ICONT(1)<br/>DIMENSION DRACH, NERGY(1), NERGY(1</pre>                                 | <pre>A ************************************</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 11100000000000000000000000000000000000                                              |
|                  | <pre>THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          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|                  | <pre>THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINE:</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          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                                                                                                                                                                                                                   | 20000000000000000000000000000000000000                                              |

|      | COMMON /ENOS/ NCAP, NDVS, NRES, NIND, NDCS, NCS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | CAG   | 340          |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|--------------|
|      | BATA C,L,G,VC,IS/2H C,2H L,2H G,2HVC,2H I/                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | CAG   | 350          |
|      | DATA NE, NL/2HNC, 2HNL/                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | CAG   | 360          |
| С –  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | CAG   | 370          |
| C*:  | ****APPLY A ZERO-VALUED CURRENT SOURCE ACROSS THE MONLINEAR ELEMENT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | CAG   | 380          |
| C    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | CAG   | 390          |
|      | NTYPE(K)=TYPE(N)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | CAG   | 400          |
|      | TYFE(N)=IS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | CAG   | 410          |
|      | VALUE(N)=0.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | CAG   | 420          |
|      | KEY (N)=TIKEY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | CAG   | 430          |
|      | NCGHT(I)=NCT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | CAG   | 440          |
|      | NCS=NCS+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | CAG   | 450          |
| С    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | CAG   | 460          |
| ก็สะ | ****CHECK FOR A CEPENDENT NON INFOR FLEMENT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | CeG   | 470          |
| ř    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 29.10 | 420          |
| 5    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 000   | 490          |
|      | MOTING ALL OF GUILING ANY SUCCESSION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | CAG   | 500          |
|      | tratitates<br>performentes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 000   | 510          |
|      | CALL SYTERE (MARRIED TYPE DALUE STROM NTO KEY, NEDAM(ICAN), NTA(ICAN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | VCAC  | 520          |
|      | Child Children Chally Day Frei Schelden and Schender Konkilder Strick                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | C0C   | 520          |
|      | 2/3182731230-003<br>NOC -NOCA1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       | 540          |
|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |       | 540          |
|      | しめビジェくいいりリントリーローロック<br>  アニアイトリントリーローローローローロー<br>  アニアイトリントリーローローローローローローローローローローローローローローローローローローロ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | CAC   | 530          |
|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |       | 550          |
|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | LHG   | 570          |
|      | NK 19 THORE 19 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |       | 560          |
|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | LHG   | 590          |
|      | CUTE COURSE (SUPPORT COURSES AND ALL SUPPORT OF A COURSES AND ALL AND A | ILH6  | 600          |
|      | 1).(K=9,15,0.00)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | CAG   | 610          |
|      | NCS=NCS+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | CAG   | 650          |
|      | NCCHT(NCT)=NCT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | CAC   | 630          |
| C    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | CAG   | 640          |
| C*:  | ****COMBINE THE LINEAR PART OF THE NONLINEARITY WITH THE LINEAR NTWK                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | CAG   | 650          |
| С    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | CAG   | 660          |
|      | IF (COFF(K,2).ED.0.00) GO TO 102                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | CAG   | 670          |
|      | CALL CRITERT (NADD, BR, TYPE, VALUE, NEROM, NTO, KEY, NEROM(N), NTO(N), 8, VC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | CAG   | 680          |
|      | 1+COFF(K+2))                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | CAG   | 690          |
|      | ICONT(NADD)=JCONT(K)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | CAG   | 700          |
|      | UCD17(K)=0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | CAG   | 710          |
|      | HDC3=HDC3+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | CAG   | 720          |
|      | 102 IF (COFF(K,1).E0.0.00) RETURN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | CAG   | 730          |
|      | CALL CXTPRT (NADD, DR, TYPE, VALUE, NEROM, NTO, KEY, NEROM(N), NTO(N), 8, V(                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | JCAG  | 740          |
|      | 1, COFF(K, 1))                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | CAG   | 750          |
|      | ICONT(MADD)=ICONT(N)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | LAG   | 760          |
|      | ICC/17(11)=0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | CAG   | 770          |
|      | NDC3+NDC3+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | CAG   | 7 <b>E</b> 0 |
|      | RETURN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | CAG   | 790          |
| C    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | CAG   | 800          |
| C≯   | ****INDEPENDENT TYPE NONLINEARITY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | CAG   | 810          |
| Ċ    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | CAG   | 620          |
| -    | 104 IF (COFF(K+1),EQ.0.00) RETURN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | CAG   | 830          |
|      | 17 (NTVRE(K).ED.NC) 60 TO 103                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | CAG   | 840          |
|      | IF (NTYFE(K).E0.NL) 60 TO 103                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | CAG   | 850          |
|      | EQUL CXTERT (HADD, DP, TYPE, VALUE, NEROM, NTO, KEY, NEROM(N), NTO(N), 5, 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | CAG   | 860          |
|      | 10855(%,10)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | CAG   | 870          |
|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | CAG   | 830          |
|      | PT1121                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | CAC   | 890          |
|      | 105 COLL CATEDI (HADD. D. TYPE, UN US. NEROM. NTO.KEY. NEROM(N). NTO(N). 2.C.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | CAG   | 500          |
|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | DAD   | 910          |
|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 293   | 920          |
|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | CAG   | 930          |

| 108 RECVAL=1.0000/CC77(K,1)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | CUS                  | 540               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-------------------|
| EUCE PRIMER CUDDR PS USES ACES REROW FOR SEAVEROUS AND CONSER                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | - 2 1 - 1            | 209               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0.00                 | 1 JU<br>1 C C C C |
| 1110-111671<br>BETRICH                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | C111.1<br>(17.14)    | - e <b>n</b> 0    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0.00                 | 673               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0.00                 | 1000              |
| LIN<br>Report in the second state and the second state of the second state and the second state and the second state a                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | CE 10                | 10                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 100                  |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | a*100                |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 1000                 | Co                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | er::::::             |                   |
| 6 s 1. TENTER OF SOCIET APPORTUNE, DESCRIPTION OF A DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                      | ĒG                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | *07.0                | 20                |
| C * 2. CONSINE THESE PORCHESE DRANCHES,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | *CT.3                | ່ວ່າ              |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | *: îi                | ŝ ĵ               |
| ERRARS THIS SUD-FROGRAMMS RECERARY OF FORTRAM MAMER                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 107.5                | 110               |
| C * MER : TOTAL MUNDER OF LIMEAR ELEMENT DRANDWED                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 30.11                | 140               |
| C * ALL OTHER VARIABLE AND ARRAY MAKED AS LEFINED FREUEDUCLY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 4.C.D                | 120               |
| C * IN CUE-PROGRAMS AMAIN AND CASMUS,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 407.0                | ( (C))            |
| C o                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | \$ ( ] ( )           | 100               |
| Сжежиние в стати в стати в стати в стати и стати с с                                                                                                                                                                                                                                                                                            | ##{{{}}}             | 159               |
| C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 120                  | 190               |
| INTEGER ER(1),NFROM(1),NTO(1),KEY(1),TVFE(1),COONT(1)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 6.55                 | 110               |
| DIMENSEON VOLVE(1)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 610                  |                   |
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| 110 IF (N.EO.A) CO TO 102                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1.1                  | ( <u>)</u> )      |
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| C.                                                                 | *****            | : a #      | *****                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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| $\langle \cdot \rangle$                                            | en 1941 -        | ;          | 5166                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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|               | TNITECCO DO TUDE                                                                             | <b>~~</b> ~   |                 |
|---------------|----------------------------------------------------------------------------------------------|---------------|-----------------|
|               | LINEGER ER, ITTE                                                                             | 621           | 250             |
|               | DIMENSION ERCIJ, MERONCIJ, MIUCIJ, MERCUJ, ILGANCIJ                                          | 231           | c.00            |
|               | DIMENSION OALDE(I)                                                                           | 651           | 210             |
|               | DIMENSION REPORT                                                                             | USI           | 550             |
|               | COMMON /016/ NCONT(22).JCONT(10)                                                             | CST           | 530             |
|               |                                                                                              | CST           | 540             |
| 102           | L*3=C                                                                                        | CS7           | 250             |
|               | I=NELEM/J                                                                                    | CSï           | 280             |
|               | IF (I.EO.O) 69 79 103                                                                        | CST           | 270             |
|               | L=1                                                                                          | C57           | 230             |
|               | 31= I + 1                                                                                    | CST           | 220             |
| 104           | TE (M. S. M.                                             | CST           | 2.60            |
| •••           |                                                                                              | ns:           | - 210           |
|               |                                                                                              | 051           | 520             |
|               | IF (KEY(M) DE KEY(L)) DO TO 105                                                              | 097           | 220             |
|               | ITEMPSHERING                                                                                 | rs7           | 200             |
|               |                                                                                              | 007           | 200             |
|               | しょうり ビントス キュリーン                                                                              | 001           | 200             |
|               |                                                                                              | 007           | 200             |
|               |                                                                                              | しごう           | - 37 U          |
|               | UALUE (N) = UALUE (L)                                                                        | 651           | 220             |
|               |                                                                                              | 651           | -359            |
|               | ITENP#ER(II)                                                                                 | CST           | -460            |
|               | ER(M)=BR(L)                                                                                  | CSĩ           | -110            |
|               | DR(L)=ITENP                                                                                  | CSĩ           | 450             |
|               | ITENP=NFRONCH)                                                                               | CS7           | 420             |
|               | NFROM(M)=NFROM(L)                                                                            | CST           | 0               |
|               | NFRON(L)=ITEMP                                                                               | C51           | -450            |
|               | ITEMP=((TO:M)                                                                                | 057           | 430             |
|               | NT0(1)=NT0(L)                                                                                | 057           | 0               |
|               | NTD(L)=ITEMP                                                                                 | C 97          | 420             |
|               | 17782-77967(1)                                                                               | 257           | 380             |
|               | TYPE(11)=TYPE(1-)                                                                            | 05.7          | Ena             |
|               | TYP5(1)=17-02                                                                                | Ċ Ċ           | 1:10            |
|               | TTENPSTROUTON                                                                                | 051           | - <u>6 - 54</u> |
|               |                                                                                              | 657           | ີ່ຕິກ           |
|               |                                                                                              | 05            | ີ່ເປັກ          |
|               |                                                                                              | ne            | - È E G         |
|               |                                                                                              | 057           | - 1 G ()        |
|               |                                                                                              | 05.7          |                 |
|               |                                                                                              | rot.          | 100             |
| 100           |                                                                                              | 0.00          | 600             |
| 106           | New Market                                                                                   | 0.01          | 000             |
|               |                                                                                              |               | 0.10            |
|               |                                                                                              | - C           | 000             |
| 301           |                                                                                              | 00.0          | 6.1             |
| L             | <b>END</b>                                                                                   | 000           | 6.0             |
|               | END                                                                                          | 051           | 1.1911          |
| -             | - 20BBOOLINE_CXIESI (1.ES: LANE, OUTDER MENDULUICKEA, MIL, 3.KEAO, MILL)                     | 6171          | . 0             |
| Ç             |                                                                                              |               | C11             |
| <b>C</b> **** | 医乙基乙基苯基乙烯化 经出行 化胆酸医胆酸 一种医胆酸的 医含体的 医外外的 医外外的 化合物 化化物 机酸化合物 化化合物 化化合物 化化合物 化化合物 化化合物 化化合物 化化合物 | *L(*)         | 20              |
| C             |                                                                                              | 15 LT ()<br>  |                 |
| (***          | *** THIS SUB-PROCESSING AND AND ADDITIONED FUNCTION                                          | *171          | 50              |
| C .           | * T. HD. H FLADEH IN INT FLATBACK.                                                           | ™L'1'1        | 60              |
| C             | 3                                                                                            | *[a:j]        |                 |
| C****         | *** THIS SUB-PROPRATIS, SLONGY OF FORTRON MAMES:                                             | <b>1</b> 1    | (C)             |
| С             | * J : CAN 2264 DF 108362                                                                     | *651          | (C9             |
| С             | <ul> <li>NE + NEW BOOK 143 CLEVENE TYPE_</li> </ul>                                          | 4 (. 11)<br>1 | 103             |
| С             | ·····································                                                        | *GM           | 1.0             |
| 3             | * 117 : FILL DAVID 142 - ELON (140 MODE HANDER                                               | <b>≮</b> CFT  | 1011            |
| С             | * 112 : HELLER CHAS TO CHEHODE NUMBER                                                        | *875          | 11.14           |
| С             | <ul> <li>YEAA</li> <li>TUTE DAMAGENES AND AND AND AND AND AND AND AND AND AND</li></ul>      | +C∂T          |                 |

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| C<br>C | <b>#</b><br>* | ARRAY    | NAMES      | AS DEFI    | NI DEF | SUB-PROGRAM | AMAIN   |           | *CPT<br>*CPT | 150<br>160 |
|--------|---------------|----------|------------|------------|--------|-------------|---------|-----------|--------------|------------|
| [****  | ****          | ******   | ******     | *****      | *****  | *****       | *****   | ********* | *CPT         | 170        |
| Ē      |               |          |            |            |        |             |         |           | CPT          | 180        |
| -      | INTEGER       | ER. TYPS | Ε, Ο, Ο, Ε | , IS, R, G | ,00,00 | ,CC,VC      |         |           | CPT          | 190        |
|        | DIMENSIO      | N ER(1   | ), NERO    | M(1), N    | TO(1), | TYPE(1), VA | LUE(1), | KEY(1)    | CPT          | 200        |
| C      |               |          |            |            |        |             |         |           | CPT          | 210        |
| C****  | а опо е о     | RONCH    |            |            |        |             |         |           | CPT          | 220        |
| r      |               |          |            |            |        |             |         |           | CPT          | 230        |
| 0      | 1= 1+1        |          |            |            |        |             |         |           | CPT          | 240        |
|        | 10-0-1        |          |            |            |        |             |         |           | CPT          | 250        |
|        | TYPE(1)=      | NT       |            |            |        |             |         |           | CPT          | 260        |
|        |               | =7       |            |            |        |             |         |           | CPT          | 270        |
|        | NEROMON       | = 1      |            |            |        |             |         |           | CPT          | 280        |
|        | NTO( D-N      |          |            |            |        |             |         |           | CPT          | 290        |
|        | 22V(1)-2      |          |            |            |        |             |         |           | CP7          | 300        |
|        | - KI(())-K    | 210      |            |            |        |             |         |           | ren          | 310        |
| c      | RETORN        |          |            |            |        |             |         |           | ren          | 250        |
| L.     |               |          |            |            |        |             |         |           | CPT          | 330        |
|        | Eng           |          |            |            |        |             |         |           |              | 550        |

SUBROUTINE DETREE (NROW, NCOL, INDCOL, A, MV) NTP 10 С DIR 20 C\*\* \*\*\*\*\*\*\* \*\*\*1178 30 С ÷ \*DTR 40 Ct THIS SUB-PROGRAM PERFORMS THE FOLLOWING FUNCTION: \*DTP 50 1. FIND THE PROPER TREE FROM THE INCIDENCE MATRIX. \*DTR С -# 60 č \*DTR 70 THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINES: \*076 C## \*\*\* 80 С × 1. DIAECH \*NTR 90 С \*DTR 100 ÷ THIS SUB-PROGRAM#S GLOSSARY OF FORTRAN NAMES: C\* \*\* \*072 110 NUMBER OF ROWS IN THE INCIDENCE (A) MATRIX \*DTR S NUMBER OF ROWS IN THE INCIDENCE (A) MATRIX \*DTR S NUMBER OF COLUMNS IN THE INCIDENCE (A) MATRIX\*DTR S INDEPENDENT COLUMNS OF THE A MATRIX \*DTR С NROW 120 -С ¥ NCOL 130 c c 140 × INDCOL \*078 150 -Ć\* \*\*\*172 160 C C DTP 170 SUBROUTINE DETREE TAKES THE MATRIX A, APPLIES SUBROUTINE DIAECDIR AND FINDS THE INDEPENDENT COLUMNS IN A CLOSEST TO THE LEFT. DIR THESE INDEPENDENT COLUMNS MAKE UP THE TREE BRANCHES. DIR  $1 \pm 0$ с с 120 200 С DTR 210 220 INTEGER A, INDCOL (NROW), COL, TEMP DTR 220 230 240 DIMENSION A(MU, 1) DTR L=1 DIR TEMP=1 DTR 250 CALL DIAECH (NROW, NCOL, A, MV) DTR 260 C DTR 270 с С STEP THROUGH ROWS 976 280 220 DTR DTR 200 DD 104 K=1, NRON 210 220 330 340 С DTR Č C STEP THROUGH COLUMNS DTR **ETR** DO 102 J=TEMP, NCOL DTR DTR 250 С С С FIND INDEPENDENT COLUMNS 360 DTP: 370 DTR С С TEST IF ELEMENT EQUAL TO ONE 280 DTR 390 DIF IF (A(K,J).NE.1) GD TO 102 DTR 400 000 DTR 410 RECORD INDEPENDENT COLUMN NUMBER DTR 420 DIR 430 INDCOL(L)=J DTR 440 450 L=L+1 MR TEMP=J+1 490 DTR GO TO 104 **F**TR 470 CONTINUE DUC 480 102 104 CONTINUE DITE 420 500 RETURN DTR С DTR 510 DTR 520 END SUBROUTINE DHYBRD (NBR, NNODE, DEBUG, NPORT1, ANSCOL, II, BR, TYPE, ICONT, BHD 10 IVALUE, A, HEADER, ANS, F3, F6, MV, ME) DHD 20 С EHD 30 40 \*\*120 C\* \*DHD 50 С ¥ THIS SUB-PROGRAM PEPFORMS THE FOLLOWING FUNCTIONS: 1. PERFORM HYBRID AMALYSIS OF THE AUGMENTED LINEAR CKT. 2. ACT AS THE EXECUTIVE CALLING PROGRAM FOR PERFORMING ះ២១ភ C\* \* \* 60 C \*ESD 70¥ \* DED 63 С ×
\*DHD 90 THE HYBRID ANALYSIS. С \* С \* DMD 100 \* [\*\*\*\*\* THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINES: \*DHD 110 c c 1. DFTREE \* 1141 120 \* 2. DIAECH \*DHD 130 \* С \* 3. DPRINT \*DHD 140 ē 4. DRAECH \* DHD 150 × Ĉ \*DHD 5. DPRNT1 160 č \*DHD 170 THIS SUB-PROGRAM#S GLOSSARY OF FORTRAN NAMES: 120 C\* \*090 \*\*\* NUMBER OF AUGMENTED LINEAR NETWORK BRANCHES 120 С \* NHN ¥ NRR \* NNODE ะ กษอ 200 : DEBUG OPTION FLAG VARIABLE \* DEBUG \*กษก 210 × NPORT1 : ADDRESS FOR LOCATING FIRST COLUMN OF MATRIX A\*DHD 550 IN THE HYBRID MATRIX \*DHD 530 : ADDRESS FOR LOCATING FIRST COLUMN OF MATRIX B\*DHD : ADDRESS FOR LOCATING FIRST ROW OF MATRIX A \*DHD ANSCOL 240 ÷ #DHD 250 II ALL OTHER VARIABLE NAMES AND ARRAYS AS DEFINED IN SUB-260 ¥ \*DHD 270 PROGRAM AMAIN \*DHD \* \* DHD 280 × \*\*\*\*\* 290 \*\*B53 C\* \*\*\*\* DHB 300 C INTEGER A, TYPE, ICONT, UH, CH, DCOL (75), ICOUNT(2), COUN, BEGIN, TEMP, ST, TDHD 310 320 1N, TP, PORT, HEADER, BR, RBR(75), ANSROW, ANSCOL, DEBUG, ISTP האמ INTEGER R, G, C, E, CU, UU, CC, UC DHD 330 DIMENSION BR(1), TYPE(1), ICONT(1) DHD 340 DIMENSION VALUE(1) חאת 350 DIMENSION A(MU, 1), HEADER(300) 360 DHD DIMENSION ANS(ME, 1) 370 DHD DIMENSION F3(ME, 1), F6(ME, 1) DHD 380 COMMON /ETYPE/ R,G,L,C,E, IS, CU, UU, CC, UC DATA CH, UH/1HI, 1HU/ DHD. 390 400 האת DO 102 I=1.NER DHD 410 DCOL(I)=0 DHD 420 102 RBR(I)=0 DHD 430 С DHD 440 с С 450 DETERMINE ELEMENTS MAKING UP THE TREE DHD DHD 460 CALL DETREE (NNODE, NBR, DCOL, A, MU) DHD 470 480 0000000 64-1D 490 REORDER A MATRIX INTO FOUR CLASSES DHD 500 កម្មក TREE PORT BRANCHES (TP) 510 תאת TREE NON-PORT BRANCHES (TN) LINK NON-PORT BRANCHES (LN) 520 2. תאת з. סאמ 530 LINK PORT BRANCHES (LP) DHD 540 00000 DHD 550 DCOL CONTAINS ORDERING OF A WITH TREE BRANCHES IN LEFTMOST EHD 560 COLUMNS 570 DHD 580 DHD 590 JJ=NNODE+1 מאמ N=1 DHD 600 NO 106 J=1, NNODE מאמ 610 M=DCOL(J) กษก 650 DO 104 K=H+M IF (M.FO.K) GD TO 106 630 THE DHD **6**40 DCDL(JJ)=K DHD 650 1.+1 DHD 660 1960 B. 16 16 EHD 670 . .... DHD 680

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| ~      | 108 | DO 108 I=N.NER<br>DCDL(I)=I                                   | DHD<br>DHD<br>DHD | 690<br>700<br>710 |
|--------|-----|---------------------------------------------------------------|-------------------|-------------------|
| L<br>r |     | PEORDER DEDI INTO EDUR DI ASSES                               | DHD               | 720               |
| č      |     | ICOUNT(1) MARKS LAST PORT COLUMN OF TREE BRANCHES             | DHD               | 730               |
| Ē      |     | ICOUNT(2) MARKS LAST NON-PORT COLUMN OF LINK BRANCHES         | DHD               | 740               |
| С      |     |                                                               | DHD               | 750               |
|        |     |                                                               | มหม               | 760               |
|        |     | 1 (24)WUU1<br>T-1                                             | מהמ<br>תאת        | 780               |
|        | 110 | 1-1<br>NO 112 Mai 172                                         | DHD               | 790               |
|        |     | MM=(HER+1)*(I-1)+((3-(2*I))*M)                                | DHD               | 800               |
|        |     | ITEM=DCOL(MM)                                                 | DHD               | 810               |
|        |     | IF (TYPE(ITEM).NE.S.AND.TYPE(ITEM).NE.C.AND.TYPE(ITEM).NE.L.F | מטמעאו            | 820               |
|        | 1   | 1 - TYPE(TTEN).NE-15) GU TU TTE<br>TTENT-TODINI(T)            | nun               | 840               |
|        |     | BOOL(NHY)=BOOL(ITEM1)                                         | DHD               | 850               |
|        |     | BODI (ITEMI) = ITEM                                           | $D \bowtie D$     | 860               |
|        |     | ICOUNT(I)=ICOUNT(I)+1-((I-1)*2)                               | DHD               | 870               |
|        | 112 | CONTINUE DE LA CONTRACTION DE LA CONTRACTIONE                 | משמ               | 880               |
|        |     | 17 (1.20.27 60 10 114<br>TEOLOTIANTEOLINT(1)-1                | กษณ<br>กษณ        | 500               |
|        |     | ICUMAT(5)=N83                                                 | DHD               | S10               |
|        |     | ITZ=NDR-NNODE                                                 | DHD               | 920               |
|        |     | I=2                                                           | DHD               | 530               |
| _      |     | CO TO 110                                                     | עאט               | 940               |
| C<br>C |     | DEDDED THE A MATRIX AND THE DRIGINAL LAREL LIFTTOR TO         | ини               | 220               |
| r<br>r |     | CORRESSOND TO THE REARDERED DOOL                              | סאמ               | 970               |
| č      |     |                                                               | EHD               | S30               |
| _      | 114 | N1/≈2                                                         | DHD               | S30               |
|        |     | N=1                                                           | DRD               | 1000              |
|        |     | BEGINF1                                                       | מאמ<br>מאמ        | 1020              |
|        | 115 | TTEMEDECH (N)                                                 | DHD               | 1030              |
|        | 110 | IF (ITEN.EG.DEGIN) GO TO 120                                  | DHD               | 1040              |
|        |     | ITELP=DR(M)                                                   | DHD               | 1050              |
|        |     | BR(I)=BR(I)(EM)                                               | ם את              | 1050              |
|        |     | BRUEREND FRANKEN<br>DO 119 1-1 KNODE                          | ที่มี             | 1080              |
|        |     | TEN2-A(1-N)                                                   | DHD               | 1090              |
|        |     | A(J, M)=A(J, ITEM)                                            | DHD               | 1100              |
|        | 118 | A(J, ITEH) = TEMP                                             | DHD               | 1110              |
|        |     |                                                               | บหม               | 1120              |
|        |     | DCUL(PD=DCUL(PD)                                              | חיים<br>חיים      | 1130              |
|        |     | R0 10 116                                                     | DHD               | 1150              |
|        | 150 | DCOL(11)=-DCOL(N)                                             | DHD               | 1160              |
|        |     | IF (COUN.ED.(NER-1)) GO TO 125                                | DHD               | 1170              |
|        |     | DD 124 IANNARR                                                | มหม               | 1190              |
|        |     | TE (TYEM FO T) OD TO 122                                      | DHD               | 1200              |
|        |     | 17 (TTEM.LT.0) GO TO 124                                      | DHD               | 1210              |
|        |     | DECINET                                                       | DHD               | 1550              |
|        |     |                                                               | DHD               | 1230              |
|        | 100 |                                                               | מהע<br>תאת        | 1250              |
|        | 165 | 6056-60667.<br>BMC(()):~BCC(())                               | рнр               | 1520              |
|        |     |                                                               | מאמ               | 1270              |
|        | 124 | CONTINUE                                                      | DHD               | 1580              |

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|        | 125<br>123 | DO 120 N=1.NDR<br>DEOL(H)=36D3(DEOL(N))                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | DHD<br>DHD      | 1290                |
|--------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------------|
| č      |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | DHD             | 1310                |
| L<br>C |            | KADOCT KACKDEKED H MHIKIX IO KOM ECHELON FORM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | DHD<br>DHD      | 1020                |
|        |            | CALL DIAECH (MNODE, NER, A, MU)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | DHD             | 1340                |
| С<br>С |            | PORT CORFEETURE & MOTORY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | DHD             | 1350                |
| C      |            | PHON COPOLITIC H DHININ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | DHD             | 1370                |
|        |            | DO 130 IRR,NNODE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | DHD             | 1380                |
|        |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 089<br>1141     | 1290                |
|        |            | 12001 al                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | DHD             | 1410                |
|        |            | ITENP=A(J, IFCOL)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | DHD             | 1420                |
|        | 100        | DO 130 KHINDR                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | DHD             | 1430                |
| C      | 0ن1        | 日にしたたというにいては、シートにして、システムに開始                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | BHD             | 1450                |
| č      |            | FORMULATE THE ELEMENT CHARACTERISTICS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | DHD             | 1460                |
| Č,     |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | DHD             | 1470                |
| E.     |            | TP IS THE NUMBER OF COLUMNS IN FI AND FS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 10HU<br>nun     | 1480                |
| Ē      |            | THE THE NUMBER OF COLOMNS IN F3 AND F3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | DHD             | 1500                |
| ē      |            | LP 13 THE MUNDER OF COLUMNS IN F4 AND F8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | DHD             | 1510                |
| С      |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | DHD             | 1520                |
|        |            | TREADER AND TO A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 080<br>DED      | 1540                |
|        |            | LN=100001(2)-NNODE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | DHD             | 1550                |
|        |            | LP=HBR-ICOUNT(2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | DHD             | 1550                |
|        |            | PBRYSTP#LP                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 비난지             | 1570                |
|        |            | ANRON (ANRO)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | DSD             | 1590                |
|        |            | ANGCOL+NOR+PORT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | DHD             | 1600                |
|        |            | WRITE (6,272)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | DHD             | 1610                |
|        |            | 17 (PPLED, 0) 60 70 132<br>TE (DEDUC NE 1) 00 70 132                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | DHD<br>DHD      | 1620                |
|        |            | $M^{(1)}(0,000,001,00,00,000,000,000,000,000,000$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | DHD             | 16-1                |
|        | 132        | 1 ÷ • • • • • • • • • • • • • • • • • •                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | DHD             | 1650                |
|        |            | IF (TN.50.0) GO TO 134                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | DHD             | 1650                |
|        |            | 17 (ULLUSVAL.1) 50 (ULLU9<br>URIVE (0.0723) (D2(1).14(NNORE)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1 A.9<br>090    | 1670                |
|        | 134        | U-IMODEAL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | DHD             | 16.90               |
|        |            | J2#11002342N                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | PHD             | 1.00                |
|        |            | 17 (LH/E0/0) 60 70 105                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | DEUD<br>DEUD    | $\frac{1.10}{1.20}$ |
|        |            | 16 (82606.62.1) (U 10 105<br>8277- 165283) (D2(1).1=4.14)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | - 1949<br>1949  | 1/31                |
|        | 133        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | DED             | 1.4                 |
|        |            | 17 (LP.EO.O) GO TO 133                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | DED.            | 1750                |
|        |            | IF (DEDUG.NE.1) GO TO 133<br>Natur (C. 200), (Da(I) Ital N22)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 1040            | 1.6                 |
| c.     |            | RKTIT (B)420) (178(T)+T+9)108)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $\mathbf{P}(0)$ | 1.8                 |
| č      |            | ZERO ONS MOTREX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | D: 1D           | 1.50                |
| С      |            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | - D.(D)         | 1500                |
|        | 133        | - DU 1999 1914 GW3 499<br>- カカー143 - 141 - Chigan 19                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 120             | -1891<br>-1891      |
|        | 140        | na martinazza<br>ERBCEDD                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | ERD.            | 1830                |
|        |            | EO 144 1 1. HEORT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | - BHB           | 1840                |
|        |            | BD 1/2 U-1.7N                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | - ECD<br>0120   | 1850                |
|        | 142        | 1 - የርዲታመታቸው መጠ<br>በጣ 123 - 1511 11                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | DHD             | 1871                |
|        | 144        | and and set of the set | DHD             | 188                 |

| C .    | 145<br>148 | <pre>KOUNT=ICOUNT(1) K=0 J=1 DD 145 I=1.NER     ITEM=BR(I) RBR(ITEM)=I IF (DEBUG.NE.1) GD TO 148 WRITE (6.282) TP.TN.LN.LP WRITE (6.282) TP.TN.LN.LP WRITE (6.284) (BR(I),I=1.NBR) KOUNT=KOUNT+1 MM=DCOL(KOUNT) ITEMP=ICONT(MM) ITEMP=RER(ITEMP) IT1=PORT+J IF (TYPE(MM).E0.G.OR.TYPE(MM).E0.UC.OR.TYPE(MM).E0.CC) GD TO 152 HOL TOCE FOURCE TYPE</pre> | DHD         1820           DHD         1500           DHD         1510           DHD         1520           DHD         1530           DHD         2000           DHD         2020           DHD         2020           DHD         2020           DHD         2020           DHD         2020           DHD         2020 |
|--------|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| с<br>С |            | VULINGE SUURCE IYPE                                                                                                                                                                                                                                                                                                                                     | DHD 2020                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| С      |            | IF (KOUNT.GT.NNODE) GO TO 150                                                                                                                                                                                                                                                                                                                           | - DHD 2070<br>THD 2080                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| С<br>С |            | F2                                                                                                                                                                                                                                                                                                                                                      | - END 2080<br>END 2080                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| L      | 150        | IT2=LN+J<br>ANS(IT1,IT2)=1.<br>IF (TYPE(MM).ED.CU) GO TO 158<br>IF (TYPE(MM).EQ.UU) GO TO 158<br>FG(J,J)=-UALUE(MM)<br>GO TO 156<br>K=K+1<br>F3(J,K)=1.<br>IF (TYPE(MM) ED CU) GO TO 158                                                                                                                                                                | END 2110<br>END 2120<br>END 2120<br>END 2120<br>END 2120<br>END 2150<br>END 2150<br>END 2150<br>END 2150<br>END 2150<br>END 2150                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| с<br>с |            | IF (TYPE(MM).E0.UU) GO TO 185                                                                                                                                                                                                                                                                                                                           | - DHD 2230<br>DHD 2230<br>DHD 2230                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| č      |            | ANS(IT1.K)=-IAIIE(MM)                                                                                                                                                                                                                                                                                                                                   | 0255 GMG                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| c      |            | GO TO 156                                                                                                                                                                                                                                                                                                                                               | EH9 2250                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| C      |            | CURRENT SOURCE TYPE                                                                                                                                                                                                                                                                                                                                     | DMD 2270                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| L      | 152        | IF (KOUNT.GT.NNODE) GD TO 154                                                                                                                                                                                                                                                                                                                           | DHD 5520                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|        |            | IF (TYPE(MM).EO.UC) GO TO 166                                                                                                                                                                                                                                                                                                                           | DHD 2300                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| С      |            | IF (TYPE(NM).E0.CC) G0 T0 158                                                                                                                                                                                                                                                                                                                           | DND 5330                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| С<br>С |            | F2                                                                                                                                                                                                                                                                                                                                                      | DMD 2040<br>DMD 2050                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| _      | 154        | IT2=LN+J<br>ANS(IT1,IT2)=-VALUE(MM)<br>GO TO 155<br>K=K+1                                                                                                                                                                                                                                                                                               | END 2350<br>END 2370<br>END 2380<br>END 2380<br>END 2390                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| С<br>С |            | F7                                                                                                                                                                                                                                                                                                                                                      | DNB 2400<br>END 2410                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| č      |            | ANS(IT1.K)=1.<br>IF (TYPE(MM).EQ.UE) GD TO 155<br>IF (TYPE(MM).EQ.CE) GD TO 153                                                                                                                                                                                                                                                                         | DHD 1420<br>DHD 2420<br>DHD 2430<br>DHD 2430<br>DHD 2450                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|        | 156        | F3(J,K)=-VALUE(NA)<br>J=J+1<br>IF (KOUNT.NE.ICOUNT(2)) G0 T0 148                                                                                                                                                                                                                                                                                        | - DHD 2480<br>- DHD 2480<br>- DHD 2480                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

GD TD 174 С С CURRENT CONTROLLED Ĉ 158 IF (ITEMP.GT.TP) GO TO 160 0000 F5 IT2=NPORT+ITEMP ANS(IT1, IT2)=-UALUE(MM) GO TO 153 160 IF (ITEMP.GT.NNODE) GO TO 162 IT=ITEMP-TP FS(J,IT)=-VALUE(MM) GD TO 155 162 IF (ITEMP.GT.ICOUNT(2)) GO TO 164 IT=ITEMP.NDDE 000 F7 ANS(IT1,IT)=-VALUE(MM) GG TO JES 164 IT=ITENP-ICOUNT(2) 000 FЗ IT2=NER+TP+IT ANS(IT1, IT2)=-UALUE(MM) 60 70 153 С С С UDLIAGE CONTROLLED 165 IF (ITEMP.GT.TP) GD TO 153 000 F1 IT2=NBR+ITEMP ANS(IT1, IT2)=-VALUE(MM) 60 TO 155 163 IF (ITENP.GT.HNODE) GO TO 170 ITEITENP-TP С С С F2 115=711+11 ANS(IT1+IT2)=-VALUE(MM) 60 TO 103 170 IF (ITEMP.GT.ICOUNT(2)) 60 TO 172 IT=ITENP-MMODE F3(J,IT)=-VALUE(MM) CO TO 153 172 IT=ITENP-ICOUNT(2) 000 74 172=NPORT+TR+11 AND(11),172)=-VALUE(MM) GD TO 155 174 17 (BEDUG.NE.1) GD TO 195 IF (LH.E0.0) GO TO 184

DHD 2490 DHD 2500 DHD 2510 DHD 2520 DHD 2530 DHD 2540 DHD 2550 DHD 2560 DHD 2570 DHD 2580 DHD 2590 DHD 2600 DHD 2610 DHD 5650 DHD 2630 DHD 2640 DHD 2650 DHD 2860 DHD 2670 DHD 2080 DHD 5630 DHD 52.00 DHD 2710 DHD 2720 DHD 2730 DHD 2740 DHD 2750 DHD 2760 DHD 2770 DHD 2780 DHD 2790 DHD 5800 DHD 2810 DHD 5850 DHD 5830 DHD 2840 DHD 2850 DHD 5820 DHD 2870 DHD 2880 0693 GHU DHD 5300 DHD 2910 DHD 5830 DHD 5850 DHD 2940 DHD 2950 DHD 5200 DHD 2970 DHD 5880 DHD 5990 DHD 3000 DHD 3050 DHD 3030 DHD 3040 DHD 3050 DHD 3060 CHD 3070 BHB 3080

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| 000    |            | WRITE F3 FOR DEBUG RUN                                                                                           |
|--------|------------|------------------------------------------------------------------------------------------------------------------|
| L      | 176        | WRITE (6,285)<br>ITI=1<br>IT2=LN<br>IF ((IT2-IT1).GT.10) CD TD 180<br>IF (IT2.ED.IT1) CD TD 184<br>URITE (6,285) |
|        | 178        | DO 178 I=1.NPORT<br>VRITE (5.290) (F3(I.1).1=II1.II2)                                                            |
|        | 180        | GO TO 184                                                                                                        |
|        | 182        | WRITE (6,283)<br>DO 182 I=1,MPORT<br>WRITE (6,280) (F3(I,J),J=IT1,IT2)                                           |
| ~      | 184        | GO TO 176<br>IF (TP.E0.0) GO TO 194                                                                              |
| C      |            | WRITE FS FOR DEBUG RUN                                                                                           |
| С      | 186        | WRITE (6,292)<br>IT1=1<br>IT2=TN<br>IE ((IT2-II1).6I.10) 60 TO 190                                               |
|        | 183        | IF (IT2.E0.IT1) GO TO 194<br>URITE (G.238)<br>DO 183 I=1.NPORT<br>URITE (G.290) (FG(I,J),J=IT1.IT2)              |
|        | 190        | GU (U 15)<br>IT2=IT1+9<br>WRITE (5,288)                                                                          |
|        | 192        | DO 192 I=1,HPORT<br>WRITE (G.290) (F6(I,J),J=IT1,IT2)<br>IT1=IT2+1                                               |
|        | 194        | GU TU 185<br>WRITE (6,294)<br>CALL DPPIHT (ANSCOL,ANSROW,ANS,ME)                                                 |
| C      |            | ZEPO OUT FG                                                                                                      |
| С      | 196        | IF (TH.EO.0) GO TO 20S<br>DO 204 J=1.TM<br>KK=TP+J<br>DO 204 I=1.NPORT<br>IT1=PORT+I<br>JE (JH.EO.0) GO TO 200   |
| С<br>С |            | CHANGE F7                                                                                                        |
| С      |            | DD 193 K=1.LN                                                                                                    |
| ~      | 193<br>200 | LK=NMODE+K<br>ANS(IT1+K)=ANS(IT1+K)=(F6(I+J)+FLOAT(A(KK+LK)))<br>IF (LP+E0+0) GD TO 204                          |
|        |            | CHANGE F8                                                                                                        |
| L      |            | DO 202 K=1.LP<br>LK=ICDUNT(2)+K                                                                                  |

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IT2=NER+TP+K DHD 3690 503 ANS(IT1, IT2)=ANS(IT1, IT2)-(F5(I, J)\*FLOAT(A(KK, LK))) DHD 3700 DHD 3710 204 CONTINUE DHD 3720 DHD 3730 CCC ZERO OUT F3 DHD 3740 205 IF (LN.E0.0) GO TO 215 3750 DHD DO 214 JULI, LN LKENNODE+J DHD 3760 DHD 3770 DHD 3780 DHD 3780 DO 214 J=1, NPORT IT1=PCRT+I EMD 3800 IF (TH.E0.0) CO TO 210 EMD 3800 DMD 3610 DMD 3830 EMD 3830 EMD 3830 0000 CHANGE F2 DO 200 K=1.TN KK=TP+K DHD 3850 IT2+LN+K AN3(IT1,IT2)=AN3(IT1,IT2)-(F3(I,J)\*FLOAT(-A(KK,LK))) IF (TP.E0.0) GO TO 214 DHD 3830 203 DHD 3870 END 3870 END 3880 END 3890 END 3800 END 3910 210 000 CHANCE F1 DHD 3820 DHD 3820 DHD 3830 DO 212 K=1,7P 172=hDR+K DHD 3940 515 ANS(111,112)=ANS(111,112)~(F3(1,J)\*FLOAT(-A(K,LK))) 214 CONTINUE DHD DHD 3560 000 DHD 2570 DHD 3520 FILL ANS MATRIX 21S IF (DEDUC.ME.1) GO TO 213 WRITE (S.223) CALL DERINT (ANSCOL,ANSROW,ANS,ME) 218 IF (LH.ED.0.GR.TP.E0.0) GO TO 222 PHD 1990 EHD 4000 DHD 4010 DHD 4020 DHD 4020 CCC DHD 4040 STORE D1 DHD 4050 DO 220 I=1,TP DO 220 J=1,LU K=UNODE-J DHD 40E0 DHD 4070 DHD 4080 220 ANS(I,J)=h(I,K) DHD 4090 555 FC=711+1 DHD 4100 ITENP=TP+1 DHD 4110 IF (ITEMP.GT.FORT.OR.LC.GT.NPORT) GO TO 226 DHD 4120 DHD 4130 000 DHD 4140 STORE -D4 TRANSPOSE DKD 4150 DO 224 IHITEMP+PORT UUHLC+I-ITEMP+NNODE DO 224 UHLC+NPORT DHD 4160 DHD 4170 PHD 4180 II=J+1-UC+TP DHD 4190 224 ANS(1,J)=-n(11,JJ) 225 IF (Th.E0.0) 60 TO 230 DHD 4200 DHD 4210 DHD 4550 000 STOPE WHIT MATRIX ABOVE F5 BHB 4230 DED 4240 DHD 4250 DO 223 Jel.TP EHD 4260 1.0 -117027+7 223 ANS/TAUD: 1.0 EHD 4270 230 IF (LP.20.0) GD TO 234 DHD 4280 .

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          STORE UNIT MATRIX ABOVE F4
      II=TP+1
      DO 232 I=II, PORT
         LD=NPORT+I
  232 ANS(I,LD)=1.0
  234 ITEMP=TP+1
      LF=LD+TP
      LE≈LD+1
      IF (ITEMP.GT.PORT.OR.LE.GT.LF) GO TO 238
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C
           STORE -D2 TRANSPOSE
      DO 236 I=ITEMP.PORT
         JJ=I-ITEMP+ICOUNT(2)+1
      DO 235 J=LE+LF
         II=J+1-LE
  236 ANS (1, J) =- A(11, JJ)
  238 LE-LF+LP
      LD=LF+1
      IF (TP.EO.O.OR.LD.GT.LE) GO TO 242
C
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          STORE D2
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      DO 240 I=1.TP
      DO 240 J=LD,LE
         K=ICOUNT(2)+1+J-LD
  240 ANS(I+J)=A(I+K)
  242 IF (DEBUG.NE.1) GD TO 244
      WRITE (6,298)
      CALL DPRINT (ANSCOL, ANSROW, ANS, ME)
С
С
          REDUCE ANS MATRIX TO ECHELON FORM
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  244 CALL DRAECH (NBR, ANSCOL, ANSCOL, 1, 1, ANS, MU, ME)
      ZER0=1.0000E-15
      IF (DEBUG.NE.1) GO TO 245
      WRITE (6,300)
      CALL DPRINT (ANSCOL, ANSROW, ANS, ME)
  246 DO 248 I=1.NBR
      DO 248 J=1, NPORT
         II=NBR+1-I
         IF (ABS(ANS(II,J)).LE.ZERD) ANS(II,J)=0.0
         IF (ANS(II, J).NE.0.) GO TO 250
  248 CONTINUE
  250 II=II+1
С
С
С
          FILL COLUMN HEADING VECTOR FOR FINAL DPRINT OUT
      J=0
      IF (TP.E0.0) GO TO 254
      DO 252 I=1.TP
         IT=2*1
         HEADER(IT)=BR(I)
HEADER(IT-1)=CH
         12=2*(PORT+I)
         HEADER(I2)=BR(I)
  252 HEADER (12-1/=UH
  254 IF (LP.E0.0) G0 TO 258
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DHD 4290

DHD 4300 DHD 4310

DHD 4320

DHD 4330

DHD 4340

DHD 4350 DHD 4350 DHD 4370

DHD 4330

DHD 4390

PHD 4400

DHD 4410 DHD 4420

DHD 4420

DED 4440

DHD 4450 DHD 4460

DHD 4470

DMD 4480

ESB 4420

DHD 4500 DHD 4510

EHD 4520

DHD 4530

DHD 4540 DHD 4550

PHD 4550

DHD 4570

DHD 4530

DHD 4590

DHD 4500

DHD 4010

DHD 4620

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DHD 4650 FHD 4860

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DHD 4710

BHD 4720

DHD 4730

DHD 4740 DHD 4750

DHD 4760

DHD 4770 DHD 4780

DHD 4790

DHD 4800

DEND 4010

DHD 4820

PHD 4830 PHD 4840

DHD 4850

DHD 4850

BHD 4870

DHD 4680

|        |     | J=TP<br>DD 256 I=1,LP                                                 |     |   | DHD<br>DHD    | 4890<br>4900 |
|--------|-----|-----------------------------------------------------------------------|-----|---|---------------|--------------|
|        |     | <u>↓</u> =↓=↓                                                         |     |   | DKD           | 4910         |
|        |     | (=I+1COUNT(2)                                                         |     |   | DHD           | 4920         |
|        |     | HEADER(IT)=BR(X)                                                      |     | : | 0HD           | 494(         |
|        |     | HEADER(IT-1)=UH                                                       |     |   | DHD           | 4950         |
|        |     | 12=2*(PORT+TP+1)                                                      |     |   | DHD           | 4960         |
|        | 250 |                                                                       |     |   | 0HD<br>nun    | 4970         |
|        | 523 | TT=4×2027                                                             |     | : | מאט<br>מאמ    | 4990         |
|        | 200 | NPORT1=NPORT+1                                                        |     |   | מאמ           | 5000         |
|        |     | DO 230 I=II.NER                                                       |     |   | DHD           | 5010         |
|        | 250 | DU 260 J=M20012, ANSCOL<br>TE (ARS(AMS(T, 1))   E ZERD) ANS(T, 1)-0 0 |     | : | - נואט<br>האח | 5020         |
|        | 200 | IF (DEBUG.NE.1) GO TO 282                                             |     |   | מאם<br>מאמ    | 5040         |
| С      |     |                                                                       |     |   | DHD           | 5050         |
| č      |     | DPRINT FINAL AND MATRIX FOR DEBUG RUN                                 |     |   | DHD           | 5060         |
| L      |     | CALL REDATT (IT. NEGET) ANECOL II. NEE HEADER, ANG. ME)               |     | : | มหม<br>กษณ    | 5070         |
|        | 282 | IF (II.EO.NER) GO TO 288                                              |     | : | DHD           | 5090         |
| С      |     |                                                                       |     |   | DHD           | 5100         |
| C      |     | BACK SUBSTITUTE FINAL ANSWER MATRIX                                   |     |   | DHD           | 5110         |
| Ľ      |     | 171-089004-11+1                                                       |     | : | <u>האם</u>    | 5120         |
|        |     |                                                                       |     |   | מאמ           | 5140         |
|        |     | DO 264 I=IT2, ANSROW                                                  |     |   | DHD           | 5150         |
| č      |     | AND/ TOUL TOUN TO DAUGT FURMENT USER TO TOD FURMER ADD                | -   |   | DHD           | 5160         |
| ř      |     | HMS(IKW,ICC) IS PIVUI ELEMENI USED IU ZERU ELEMENIS HBUV              | -   | : | nen.          | 5120         |
| C      |     | IRN=ANSROW+IT2-I                                                      |     |   | DHD           | 5190         |
|        |     | ICL=NPGRT+IT1+IT2-I                                                   |     |   | DHD           | 5200         |
| c      |     | IT3≏IR₩-1                                                             |     | : | DHD<br>Run    | 5210         |
| ř      |     | HEROW ZEROING OUT ABOUE PIUNT                                         |     |   | nen.          | 523(         |
| č      |     |                                                                       |     |   | DHD           | 5240         |
|        |     | DO 284 J=II.I73                                                       |     |   | CHD           | 5250         |
| r      |     | B≈ANS(J,ICL)                                                          |     |   | םאם<br>העת    | 5260         |
| č      |     | K=COLUMN CHANGING OF JTH RDW                                          |     |   | DHD           | 5280         |
| Ĉ      |     |                                                                       |     |   | DHD           | 5290         |
|        |     | DO 264 K=ICL, ANSCOL                                                  |     |   | DHD           | 5300         |
|        | 254 | ANG(J,K)=ANG(J,K)=B*ANG(1RW,K)<br>DD 2008 1-11,NBD                    |     |   | มหม<br>ทยุท   | 5311         |
|        | 203 | DD 283 JENPORTI, ANSCOL                                               |     |   | рнр           | 5330         |
|        | 263 | IF (ADS(AMS(I,J)).LE.ZERD) ANS(I,J)=0.0                               |     |   | DHD           | 5340         |
| č      |     |                                                                       |     |   | DHD           | 5350         |
| L<br>C |     | RAKINI FINAL AND MATKIX                                               |     |   | DHD<br>DHD    | 5350         |
| C      |     | IF (DEBUG.NE.1) 60 TO 270                                             |     |   | DHD           | 5380         |
|        |     | CALL EPRHTI (IT, NPORTI, ANSCOL, II, NBR, HEADER, ANS, ME)            |     |   | DHD           | 5390         |
| ~      | 270 | RETURN                                                                |     | : | DHD           | 5400         |
| Ļ      | 272 | E02097 (1997//)                                                       |     |   | มหก<br>เ      | 5420         |
|        | 274 | FORMAT (1M0, 10HTREE PORT BRANCHES, /30(1X, I2))                      |     |   | DHD           | 5430         |
|        | 276 | FORMAT (100, SCHTPEE HOM-PORT BRANCHES, /30(1X, 12))                  |     |   | DHD           | 544(         |
|        | 273 | FORMAL (1MO, 12MLTRK NON-PORT BRANCHES,730(1X,12))                    |     |   | nHn.          | 545          |
|        | 522 | FORMAT (1MO, SHTP = $, I3/, GH TN = , I3/, GH LN = , I3/, GH$         | LP  | Ξ | DHD           | 547(         |
|        |     | 1,13)                                                                 | - 1 |   | DHD           | 5480         |

284 FORMAT (1N0, 2HER,40(1X,12)) 285 FORMAT (///, 18H F3 BEFORE ZEROING) THD FORM END 5500 288 FORMAT (1X) END ESCO 290 FORMAT (1X, 10(511.4, 1X)) PHD 5520 292 FORMAT (1//, 10(211.4,1K)) 292 FORMAT (///, 16H FS DEFORE ZEROINS) 294 FORMAT (///, 26H ANS MATRIK BEFORE ZEROINS) 295 FORMAT (///, 26H ANS MATRIK AFTER ZEROINS) 293 FORMAT (///, 26H ANS MATRIX HITH D VALUES FILLED IN) 300 FORMAT (///, 36H ANS MATRIX REDUCED TO ECHELON FORM) END 5520 END 5520 END 5540 END 5550 IND 5550 IND 5570 END EEDO С END ESSO FND FCH FCH SUBROUTINE DIAECH (NROW, NCOL, A, MV) 10 С 20 \*\*\*\*\*]]]]} 5.0 С 35 \*1011 ch THIS SUB-FROGRAM PERFORMS THE FOLLOWING FUNCTION: \*DIN 1. NANIPULATE THE INCIDENCE (A) MATRIX INTO ECHELON FORM \*DIN 5-0 [\*\*\*\*\* C E0 \*£[]] 70 С \* THIS SUB-PROGRAM#S GLOSSARY OF FORTRAN NAMES: NROW : MUMBER OF ROWS IN THE A MATRIX NCOL : MUMBER OF COLUMNS IN THE A MATRIX \*DEN 20 **C\*\*\*\***\*\* \*2711 \*10111 50 C \* 100 С С -5 \* 5011 1.10-34 120 ΤH 30 С .40 B10 270 ē SUBROUTINE DIAECH MANIPULATES MATRIX A INTO ECHELON FORM 150 č PEN PCH 100 INTEGER A, C, G, GPLU31, P, B DIMENSION A(MU, 1) 170 100 100 100 ETH DCH C=1G≈1 PIII PIII 200 102 00 116 I=G, MRON 810 IF (A(I,C).E0.0) GD TO 115 PÉR EUR 220 000 220 240 INTERCHANGE I AND G ROW TO GET NONZERO PIVOT I EU IF (1.E0.6) 60 70 103 FEH230 230 DO 104 K≈C,HCOL T I H 1 211 D7(1 270 D=A(I,K) 200 200 A(I,K)=A(G,K) A(G,K)=B 7 211 1-111 1-111 300 230 104 CONTINUE С С : 0 220 320 NORMALIZE ROW TO GET POSITIVE NUMBER FOR PIVOT D'EH. 1-711 С IF (A(G,C).GT.0) GO TO 110 DO 108 K=C,NCOL 340 150 14741 106 1-711 230 270 200 200 Ъ. П 103 A(G,K)=-A(G,K) Diff IF (G.GE.HROWD RETURN 110 1011 000 ZERO COLUMN DELON PIVOT  $\mathbf{i} \in \mathbb{N}$ 1 []] 1 []] 400 GPLUS1=G+1 410 420 420 420  $\mathbf{p}_{\mathrm{eff}}$ DO 114 P=GPLUS1+NROW DHA(P,C) IF (B.50.C) CO TO 114 ТЦ. 1973) 1933 400 10 112 K≈C,NCCL H(F,K)≃-D≭A(G,K)+A(P,K) 1-711 112 CONTINUE 410 470 1411 114 1911 G=G+1 C=C+1 THE 400

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|          |                 | <u>60 70 102</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | DIH               | 500        |
|----------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------------|
|          | 115             | LENTINUL<br>II (C CT NDEUD PITUDN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | DIH               | 520        |
|          |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | DIH               | 530        |
|          |                 | GD 70 102                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | DIH               | 540        |
| С        |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | DIH               | 550        |
|          |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | DIH               | 550        |
| Ċ        |                 | SEEKUDITUT EHKIVI (HUPCOT) HUPKOMA HUPA UE)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1171              | 20         |
| Ľ≉       |                 | 갧숺갧숺갧숺댰갼갼갼걙줂춙춙춙슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                   | 30         |
| ē        |                 | ×                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | *BPT              | 40         |
| C∻       | ****            | ** THIS SUB-FROGRAM PERFORMS THE FOLLOWING FUNCTION:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | *DPT              | 50         |
| ç        |                 | * 1. PRINT THE ENTIRE HYBRID MATRIX FOR DEBUG RUN.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | *027              | 60         |
| 5        |                 | *<br>** THIS CHR.BRARDAM-C CLOSSARY OF TRATION (149147) 55:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | ≮#21<br>#D⊃T      | 7 U<br>8 O |
| 10       |                 | WA THIS EQUTROUGRAPHS GLUSSMAN OF FURTRAN VARIABLED;<br>W ANTER DISCHARTS OF COURSEN TO THE BURGED (ANS) MATRIX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | *027              | 50         |
| č        |                 | * AMERICA INTERIOR OF ROAS IN THE HYBRID MATRIX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | *1777             | 100        |
| č        |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | *DPT              | 110        |
| C≈       | ****            | 탒슻콊숺숺嫾슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | **D21             | 120        |
| 12       |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 027               | 130        |
| C.       |                 | SORYODITAT DEVILUE DEVILUE INT FULTYE HUZ VELIKIX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | しても               | 140        |
| С<br>Г   |                 | PRINTS ENSON DRVS BY ENSON ON UMNS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | DF1<br>DP7        | 160        |
| č        |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>EPT</b>        | 170        |
|          |                 | INTEGER ANSOL, ANSROW                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | DPT               | 180        |
|          |                 | DIMENSION ANS(ME, 1)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | DPT               | 120        |
|          |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 177               | 200        |
|          | 103             | 112-FINELUL<br>12 ((120-12)) CT 8) CO 70 10C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 1/21<br>not       | 220        |
|          |                 | IN (112 IN 171) DITUDN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 001<br>027        | 220        |
| C        |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ĨP7               | 240        |
| ē        |                 | LESS THAN 10 COLUMNS LEFT TO PRINT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | EPT               | 250        |
| С        |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | D21               | 220        |
|          |                 | NRITE (G. 110)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | E51               | 520        |
|          | 101             | LU 199 1919 (MARKEN<br>Natur (R. 119) (AND(T. 1) 1-171 173)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 151               | 200<br>200 |
|          | 104             | REFER                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Ter               | 200        |
|          | 103             | TT2=TT1+9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>D</b> PT       | 310        |
| C        |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | EPT               | 350        |
| £        |                 | MORE THAN 10 COLUMNS LEFT TO PRINT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>F</b> 27       | 330        |
| C        |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1971              | 240        |
|          |                 | NKILL (6+110)<br>Fo 109 Tet.(NSD0)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                   | 200        |
|          | 102             | 12777 (S.112) (ANS(7.1), 1=771, 772)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | DP7               | 370        |
|          | 200             | 171=172+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 027               | 380        |
|          |                 | GO TO 102                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | PPT               | 390        |
| С        |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <u>r</u> pt       | - 400      |
|          | 110             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1671              | 420        |
| r        | 777             | 「15(4)時1」(1722年11・69-177)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 1.51              | 420        |
|          |                 | ระก                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | DP 7              | 440        |
|          |                 | EVEROUTINE BERNTI (MER, ACL1, ACL2, ARW1, ARW2, HEADER, ANS, ME)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | DP1               | 10         |
| C        |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | $\Gamma P1$       | 60         |
| -E*      | \$K (\$ \$ \$ ) | 枩抣鈶鈶鈶粅枩欱欱欱欱欱欱欱欱欱欱欱欱欱欱欱欱拢拢拢蒆褬礛藛蒆蒆蒆蒆蒆蒆蒆蒆蒆蒆蒆蒆蒆蒆蒆蒆蒆 <mark>獉獉獉獉獉褬褬</mark> 斄 <b>픛褬褬</b><br>乛                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | **1001            | - 30       |
| <u> </u> |                 | 9<br>28 THER CHALTARCAN RECEPTED THE FOULDHING FUNCTIONS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | * EC1<br>* FD1    | - 40<br>50 |
|          | .a. 3575        | AND THE FURTHER AND THE REAL PRODUCTS FOR HUBBLE THE MADE THE THE MADE THE | erinen<br>telinen | - 50<br>60 |
| ć        |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | + 271             | 70         |
| Č.       | *****           | ** THIS EUD-PRODRAMES GLOSSARY OF FORTRAN NAMES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | ≤DP1              | 03         |
| Ċ        |                 | HER : TOTAL HUNDER OF COLUMNS IN THE DESIRED PART                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | * DP 1            | 50         |

ż

| č      |      | <ul> <li>ACL1 : FIRST COLUMN OF THE DESIRED PART</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | *021             | 100        |
|--------|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|------------|
| C      |      | * ACL2 : LAST COLUMN OF THE DESIRED PART                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | *0P1<br>*DD1     | 110        |
| L<br>C |      | <ul> <li>FIXUL : FIXOL RUN UF THE DESIGED FART</li> <li>ARUD : LAST RUN UF THE RESIDED FART</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | *1771            | 120        |
| r      |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | *DD1             | 120        |
| ň      |      | * ANS : NYERTE MATRIX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | *D⊇1             | 150        |
| õ      |      | * ME : ROW DIMENSION OF ANS IN THE CALLING PROGRAM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | *DP1             | 160        |
| ē      |      | *                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | *DP1             | 170        |
| C+     | ***  | *********************                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | *⊹BP1            | 180        |
| С      |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | DP1              | :50        |
| С      |      | SUBROUTINE DERNTI PRINTS ONLY THE DESIRED PART OF THE ANS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | EP1              | 200        |
| ç      |      | MATRIX BESCRIBING THE PORT EQUATIONS ALONG WITH THE COLUMN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | LP1              | 210        |
| č      |      | HEADINGS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 1.21             | 550        |
| L      |      | INTEGER & REARED ACL & ACL 2 ARUI ADUS HES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ビビナ              | 230        |
|        |      | DIMENSION HEADED(200)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 1771             | 250<br>250 |
|        |      | DIMENSION ANS(ME.1)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | DP1              | 230        |
|        |      | ITM2=ACL1-1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Î P Î            | 270        |
|        |      | 171=1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | LP1              | 200        |
|        | 102  | IT2=HDR                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | EP (             | 220        |
|        |      | IF ((172-171).67.19) 60 70 105                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | DP1              | 200        |
|        |      | IF (IT2.E0.IT1) RETURN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | EP1              | 310        |
| C      |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1121             | 320        |
| Ľ      |      | LESS OR EDORE TO COLORINS TO PRIMI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1.71             | 520        |
| 0      |      | URITE (6.110) (HEADER(1), 1=771, 172)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 12:              | 550        |
|        |      | ITM1=ITM2+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | E21              | 350        |
|        |      | DO 104 I=ARU1, ARU2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | DP1              | 370        |
|        | 104  | WRITE (G,112) (ANS(I,J),J=ITM1,ACL2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | E21              | 330        |
|        |      | RETURN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | rpi              | 390        |
| _      | 106  | 172=171+19                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | DP1              | 400        |
| C      |      | MODE THAN TO COLUMNO TO DEFINE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1-1              | 43.0       |
| с<br>С |      | MURE THHIT TO COLOMING TO PRIME                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1.71<br>DP1      | 270        |
| Ļ      |      | WRITE (6,110) (HEADER(I), I=IT1, IT2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | ĒP1              | 440        |
|        |      | ITM1=ITM2+1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | DP1              | 430        |
|        |      | ITM2=ITM1+9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | EP1              | 460        |
|        |      | DO 108 I=ARW1, ARW2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | DP1              | 470        |
|        | 108  | WRITE (6,112) (ANS(I,J),J=17M1,ITM2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 191              | 400        |
|        |      | 111=112+1<br>CO TO 102                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1001.<br>1001    | 420<br>E00 |
| C      |      | GO 10 10C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 121              | 510        |
| 0      | 110  | FORMAT (1H0,10(4X,A1,12,5X))                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>D</b> P1      | 0.92       |
|        | 112  | FORMAT (1H0,10(E11.4,1%))                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | DP1              | 530        |
| С      |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | DP1              | E40        |
|        |      | END                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | DP1              | 550        |
| ~      |      | SOBKOOLINE DRAFCH (U''V''WHKK''KOMI'COFI'HN'WA'WE)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Lisi<br>neur     | 20         |
| Ľ,     |      | B. 这些公司会会会会会会会会会会会会会会会会会会会会会会会会会会会会会会会会会会会会                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1001<br>880001   | 2.0<br>70  |
| C      |      | *                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | *2511            | -10        |
| Č*     | **** | ** THIS SUB-FROGRAM PERFORMS THE FOLLOWING FUNCTION:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | $\Sigma$         | ຽກ         |
| С      |      | * 1. OPERATE ON THE ROWS OF THE HYDRID MATRIX TO REDUCE IT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | * 1973 H         | 60         |
| C      |      | * TO ECHELOH FORM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | * ERH            | 70         |
| C      |      | A THIR CHR ROBERAWAR ELECTROPY OF EDRERAM NAMER.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 41.5.1           | 50         |
| ີ ເ    | **** | ** INTS SULTERUGRANAS SEQUENCE OF EUKIKAAN MENED<br>** M * 1025 DOLTERUGRANAS SEQUENCE OF EUKIKAAN MENED<br>** M * 1025 DOLTERUGRANAS SEQUENCE OF EUKIKAAN MENED<br>** 1015 SULTERUGRANAS SECUENCE OF EUKIKAAN SECUENCE OF EUKIKAAN MENED<br>** 1015 SULTERUGRANAS SECUENCE OF EUKIKAAN SECUENCE OF EUKIKAAN MENED<br>** 1015 SULTERUGRANAS SECUENCE OF EUKIKAAN SECUENCE SECUENCENCENCENCENCENCENCENCENCENCENCENCENCE | 7310711          | ະມາ        |
| ř      |      | * N : LAST ROM NUMBER FOR ROM DESATION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 101101<br>101101 | 1.00       |
| č      |      | * MARK : LAST COLUMN NUMBER IN ECKELON FORM MATRIX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | *1721            | 120        |
| č      |      | * ROWL : FIRST ROW NUMBER IN ECHELON FORM WATRIK                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | *T011            | :20        |
| Ĉ      |      | * COL1 : FIRST COLUMN MUNDER IN ECHELON FORM MATRIX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 4 LAND           | 140        |

С ALL OTHER VARIABLE NAMES AS DEFINED IN SUB-PROGRAM AMAIN \*DRH 150 ē ..... #:DPH 160 \*\*\*\*DRH 170 С DBH 180 DIMENSION AD(ME,1) DRH 190 INTEGER C, G, GPLUS1, P, ROW1, COL1 DRH 200 С С DOH 210 PRAECH PERFORMS ROW OPERATIONS ON A TO REDUCE A TO ECHELON FORDRA 550 С DRH 230 COLUMNS COL1 TO MARK ARE REDUCED TO ROW ECHELON FORM WHILE THEORM ROW OPERATIONS ARE CARRIED OUT ON THE ROWS FROM MARK + 1 TO N.DRH ROWS ROW1 TO M ARE REDUCED TO ROW ECHELON FORM G IS THE ROW IN WHICH WE ARE DETERMINING THE PIVOT POINT DRH C IS THE COLUMN IN WHICH WE ARE DETERMINING THE PIVOT POINT DRH č 240 С 250 Ĉ 260 č 270 C C 989 DRH 220 C=COL1-1 DRH 200 G=ROW1 102 17 (C.EO.MARK) RETURN C=C+1 DRH 310 DRH 320 330 DRH 0000 ERH 340 FIND THE MAX NONZERO ELEMENT IN THE C COLUMN DELOW AND INCLUDING PINOT 350 DEH 360 370 BBH DRH I=0 DRH 380 ŽERO-1.000E-15 THZ=0.0 DO 104 J=5.7 DRH 390 DRH 400 DRH 410 TF (033(05(2+C)).LE.ZERO) AD(4+C)=0.0 IF (053(05(2+C)).LE.TMZ) GD TO 104 THZ=053(AD(4+C)) DRH 420 DRH 430 DRH 440 DRH 450 5:2.1 104 CONTINUE **DPH** 460 IF (THZ.50.0.0) CD TO 102 DRH 470 С DRH 480 IT THE NONZERO ELEMENT IS IN THE PIVOT ROW, DO NOT EXCHANGE ē DRH 490 C C R0!!3 DRH 500 DRH 510 DRH 520 IF (1.20.6) 60 TO 103 DRH 530 0000 ENCHANCE PINOT ROW WITH ROW HAVING NONZERO ELEMENT IN PINOT DRH 540 550 COLUMN DRH DRH 560 DO 103 K=C,H DRH 570 D=AD(I+K DRH 580 00(1+10+00(0+10) 105 AD(5+10+0 DEH 590 DRH 600 DRH 610 000 CHECK IF PIVOT POINT ALREADY NORMALIZED TO 1 DRH 620 **D**CH 630 103 IF (AD(G,C).E0.1.) GD TO 112 DCH 640 じじじ BRH 650 NORMALIZE PINOT ROW DRH 660 PRH 670 ALEMA~AB(0,0) DRH 680 DD 110 10 250 6D(G+K)=6D(G+K)/6LPHA DRH 620 DRH 700 710 720 110 17 (ADB(AD(G,K)).LE.ZERD) AD(G,K)=0.0 DCH ERH 000 **BPH** 730 CHECK IF JUST MORMALIZED PIVOT IN LAST ROW DCH 740

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| _      | 112  | IF (G.GE.M) RETURN                                                                                                                                                         | ERH           | 750                        |
|--------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|----------------------------|
| 0      |      | 2500 THE ELEMENTS RELOU THE RINGT                                                                                                                                          | DRH           | 760                        |
| r      |      | ZERU IME ELEMENTS BELUW IME FIVOT                                                                                                                                          | ERCE<br>Pipu  | 720                        |
| C      |      | GPLUS1=G+1                                                                                                                                                                 | PRH           | 750                        |
|        |      | DO 116 P=GPLUS1.M                                                                                                                                                          | DRH           | 603                        |
|        |      | B=AD(P,C)                                                                                                                                                                  | ERH           | 210                        |
|        |      | IF (ABS(AD(P,C)).LE.ZERO) AD(P,C)=0.0                                                                                                                                      | ERH           | 620                        |
|        |      | IF (AB5(AB(P,C)).EQ.0.0) GO TO 116                                                                                                                                         | E2H           | 830                        |
|        | 11.1 | $\begin{array}{c} \square \square$ | LIGH          | 840                        |
|        | 116  | HULESKYD*HULESKY<br>CONTINUS                                                                                                                                               | ECH           | ຣະມ<br>ເ                   |
|        | 110  | JE (G.G.M) RETURN                                                                                                                                                          | D:2H          | 870                        |
|        |      | G=G+1                                                                                                                                                                      | D.CH          | 830                        |
|        |      | GO TO 102                                                                                                                                                                  | DEH           | 830                        |
| С      |      |                                                                                                                                                                            | PEH           | 200                        |
|        |      | END                                                                                                                                                                        | TPH.          | 510                        |
|        |      | SUBRUUTINE ESTATE (MPURII,ANSUUL,II,MBR,MSV,DEBUG,H,B,C,D,VHLUE,H<br>19 me me me                                                                                           | 111221        | 20                         |
| r      | -    | 13+116+113+11F)                                                                                                                                                            | E ST          | 50                         |
| č,     | .*** | ***************************************                                                                                                                                    | *EST          | 40                         |
| Ĉ      |      | *                                                                                                                                                                          | *ZST          | 50                         |
| C,     | **** | ** THIS SUB-PROGRAM PERFORMS THE FOLLOWING FUNCTIONS:                                                                                                                      | *EST          | G0                         |
| Ē      |      | * 1. OBTAIN THE MATRICES IN 1.'S STATE SPACE REPRESENTATION                                                                                                                | *297          | 70                         |
| E      |      | * FUR THE RUGMENTED LINERK RETRURK.                                                                                                                                        | *221<br>#ECT  | 50                         |
| с<br>Г |      | * 2. PRINT PAR STATE SPACE DESURIFIEDD, IF REDUESTED.                                                                                                                      | NG31<br>€597  | 100                        |
| с,     | ***  | ** THIS SUE-FROGRAM≭S GLOSSARY OF FORTRAN NAMES:                                                                                                                           | *EST          | 110                        |
| č      |      | * NPORT1 : ADERESS FOR LOCATING FIRST COLUMN OF MATRIX A                                                                                                                   | WEST          | 120                        |
| С      |      | * AMSCOL : ADDRESS FOR LOCATING FIRST COLUMN OF MATRIX B                                                                                                                   | }×EST         | 130                        |
| C      |      | * II : ADDRESS FOR LOCATING FIRST ROW OF MATRIX A                                                                                                                          | *227          | 140                        |
| č      |      | * NOR : TOTAL NUMBER OF SKANCHES IN LINEAR UIRCOID                                                                                                                         | ****          | 150                        |
| L<br>C |      | <ul> <li>ADV : TURNER OF DIATE VARIABLED</li> <li>DEPUG : FLOP HARIARLE ERR PRINTING STATE FRUATIONS</li> </ul>                                                            | *≞≞.<br>⊎≣©⊽  | 120                        |
| Ē      |      | * A : MATRIX A THE SPACE DESCRIPTION                                                                                                                                       | *297<br>-     | 180                        |
| č      |      | * B : MATRIX B IN STATE SPACE DESCRIPTION                                                                                                                                  | *297          | 120                        |
| С      |      | * C : MATRIX C IN STATE SPACE DESCRIPTION                                                                                                                                  | 4:257         | 200                        |
| С      |      | * D : MATRIX D IN STATE SPACE DESCRIPTION                                                                                                                                  | *EST          | 210                        |
| C      |      | * VALUE : ARRAY OF ELEMENT VALUES                                                                                                                                          | *≃51<br>      | 220                        |
| С<br>С |      |                                                                                                                                                                            | RECT<br>RECT  | 220                        |
| Č,     | **** | <b>팤捿礉礉蘠顪顪顪</b> 艩统铊欯樕蛒瘷 <b>瘷</b> 瘷瘷瘷瘷瘷拢拢拢涗涗涂荶瘷枀袑汈汈汈荶荶袮沦沦沦沦沦沦沦沦沦沦沦沦沦沦沦沦沦沦沦沦沦                                                                                                | *257          | 250                        |
| č      |      |                                                                                                                                                                            | EST           | 630                        |
|        |      | INTEGER ANSCOL, CONN, DEBUG                                                                                                                                                | EC 7          | 510                        |
|        |      | DIMENSION VALUE(1)                                                                                                                                                         | EST           | 280                        |
|        |      | DIMENSION ANS(Ma)I)                                                                                                                                                        | 1251          | - <del>2</del> 59<br>- 500 |
|        |      | DINENSION HUNS,17, BUNS,17, UUNE,17, DUNE,17<br>DIMENSION DENOM(20)                                                                                                        | 83 H<br>175 T | 510                        |
|        |      | COMMON ZENOSZ NCAR, NOUS, NRES, NIND, NDCS, NCS                                                                                                                            | FS7           | 220                        |
|        |      | NCP1=NCAP+1                                                                                                                                                                | EST           | 530                        |
|        |      | IF (NCAP.E0.0) GO TO 104                                                                                                                                                   | EET           | 240                        |
|        |      | DO 102 J=1.NCAP                                                                                                                                                            | EST.          | 230                        |
|        | 102  | DEMON(1)=VALUE(1)                                                                                                                                                          | 1151<br>120   | 230                        |
|        | 104  | K-NCVDATIONALIA<br>14 (UTUATIONALIA INSTALIA                                                                                                                               | Li i<br>Ferr  | 3,0<br>5,20                |
|        |      | N-DUM TUNCOTINGU                                                                                                                                                           | Et T          | 220                        |
|        |      |                                                                                                                                                                            | ŪCT.          | ដុល់ព                      |
|        | 105  | DENON(I)=VALUE(K)                                                                                                                                                          | $E \in Y$     | $c_{20}$                   |
|        | 103  | NEONS =NER+1 = 11                                                                                                                                                          | 111           | -120                       |
| С      |      |                                                                                                                                                                            | 1.57          | 430                        |



```
С
С
            FILL MATRIX A
       N1=II
       N2=N1+NCAP+NIND-1
       N3=NPORT1+NEONS
       N4=N3+NCAP+NIND-1
IF (MOLT.N1) GO TO 128
       I1=0
       DO 110 I=N1,N2
           11=11+1
           J1=0
       DO 110 J=N3,N4
           J1=J1+1
  110 A(I1, J1)=-ANS(I, J)/DENOM(I1)
000
            FILL MATRIX B
       N5=ANSCOL-NCS+1
       NS=ANSCOL
       I1=0
       DO 114 I=N1,N2
           11=11+1
           J1=0
           DO 112 J=N5,NS
J1=J1+1
  112 B(I1,J1)=-ANS(I,J)/DENOM(I1)
114 CONTINUE
С
C*****FILL MATRIX C
C
       I1=0
       N1=N2+1
       N2=N2+NCS
       N3=ANSCOL-NCS-NSV+1
N4=N3+NSV
       DO 116 I=N1,N2
I1=I1+1
           J1=0
       DO 11G J=N3,N4
J1=J1+1
C(I1,J1)=-ANS(I,J)
  116 CONTINUE
C
C*****FILL MATRIX D
C
       N5=ANSCOL-NCS+1
       NS=N5+NCS
       I1=0
       DO 118 I=N1,N2
I1=I1+1
           J1=0
       DO 118 J=N5,NS
J1=J1+1
           D(I1, J1)=-ANS(I, J)
  118 CONTINUE
000
            PRINT MATRICES A, B,C , D
       IF (DEBUG.NE.1) GO TO 128
       WRITE (6,130)
```

| EST        | 440   |
|------------|-------|
| F07        | 450   |
| E91        | 430   |
| FST        | 460   |
| 231        | 400   |
| EST        | 470   |
| CCT.       | 100   |
| E 3 I      | 48V   |
| FGT        | 490   |
| 231        | -30   |
| EST        | 500   |
| 222        |       |
| 551        | 210   |
| FOT        | 520   |
| L31        | 950   |
| ESĩ        | 530   |
|            | 200   |
| ESI        | 540   |
| FET        | EE0   |
| C31        | 220   |
| FST        | 560   |
|            | 230   |
| ES1        | 570   |
| FOT        | 500   |
| C31        | 200   |
| FST        | 590   |
| Ee-        | 222   |
| E51        | 600   |
| FCT        | C10   |
| COL        | 010   |
| FST        | 620   |
| 201        | 020   |
| EST        | 630   |
| FCT        | C40   |
| 631        | 640   |
| FST        | 650   |
|            | 000   |
| EST        | 660   |
| FCT        | 670   |
| C 3 I      | PLO   |
| FST        | 680   |
| Ear        | 222   |
| EST        | 690   |
| FCT        | 700   |
| C31        | 100   |
| FST        | 710   |
| Eot        |       |
| E51        | 720   |
| FCT        | 730   |
| 231        | 130   |
| EST        | 740   |
| E C T      |       |
| E51        | 750   |
| CCT        | 700   |
| E 31       | 100   |
| FST        | 770   |
|            |       |
| 251        | 780   |
| FCT        | 790   |
| 631        | 1.30  |
| EST        | 800   |
| E ST       | 010   |
| 651        | 810   |
| FST        | 820   |
| 201        | 020   |
| EST        | 830   |
| CCT        | 040   |
| C.31       | 040   |
| FST        | 850   |
|            | 000   |
| EST        | 860   |
| FOT        | 070   |
| 631        | 010   |
| FST        | - 680 |
| 201        | 200   |
| 251        | 830   |
| FCT        | 900   |
| <u>L</u> J | 200   |
| EST        | 910   |
| Fet        | 000   |
| 221        | 360   |
| FST        | 920   |
| 201        |       |
| EST        | - 940 |
|            | 0-0   |
| C21        | 320   |
| FGT        | 920   |
| 201        |       |
| EST        | 970   |
| CCT        | 000   |
| C 3 I      | 200   |
| EST        | 590   |
| 201        |       |
| EST        | 1000  |
| CCT        | 1010  |
| C31        | 1010  |
| EST        | 1020  |
| 207        | 1000  |
| r 71       | 10.30 |

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|   |     | DO 120 I=1,NSV                   |
|---|-----|----------------------------------|
|   | 120 | WRITE (6,132) (A(I,J),J=1,NSU)   |
|   |     | WRITE (6,134)                    |
|   |     | DO 122 I=1,NSU                   |
|   | 122 | WRITE (6,132) (B(I,J), J=1, NCS) |
|   |     | WRITE (6,136)                    |
|   |     | DO 124 I=1,NCS                   |
|   | 124 | WRITE (6,122) (C(I,J), J=1, NSU) |
|   |     | WRITE (6,133)                    |
|   |     | DO 125 I=1,NC5                   |
|   | 126 | WRITE (6,132) (D(1,J), J=1,NCS)  |
|   | 128 | RETURN                           |
| С |     |                                  |
|   | 130 | FORMAT (1H1, SH MATRIX A)        |
|   | 132 | FORMAT (X,11(E10.3,2X))          |
|   | 134 | FORMAT (/,SH MATRIX B)           |
|   | 135 | FORMAT (/,SH MATRIX C)           |
|   | 133 | FORMAT (/, SM MATRIX D)          |
| 5 |     |                                  |
|   |     | END                              |

| EST        | 1040 |
|------------|------|
| ES7        | 1050 |
| EST        | 1060 |
| ESĩ        | 1070 |
| EST        | 1080 |
| EST        | 1050 |
| EST        | 1100 |
| FST        | 1110 |
| 557        | 1120 |
| 107        | 1:20 |
| 557        | 11/0 |
| LOT CT     | 1150 |
| E31<br>E87 | 1100 |
| 631        | 1100 |
| 201        | 1170 |
| ESI        | 1180 |
| EST        | 1120 |
| EST        | 1200 |
| EST        | 1210 |
| EST        | 1220 |
| EST        | 1230 |

ALC: NO. 1

| ິ                 | BROUTINE FEALNC (A, N, IA, B,            | K.L)                                                | FBC          | 10         |
|-------------------|------------------------------------------|-----------------------------------------------------|--------------|------------|
| C*******          | *****                                    | 计计计算数字母字母字母法子子 计字子字子 计字子字子 计字子字母子 化合体化化合体 化合体化合体    | *FBC         | 30         |
| Č *               |                                          |                                                     | *FEC         | 40         |
| [3*****<br>[ *    | THIS SUB-FROGRAM PERFORMS                | THE FOLLOWING FUNCTION:                             | *FBC         | 50         |
| L *               | 1. BALIACE N REAL NA                     | 1879.4.                                             | *FEC         | 70         |
| C******           | THIS SUB-PROGRAM#5 GLOSSA                | RY OF FORTRAN NAMES:                                | *FBC         | 80         |
| C *               | A : MATRIX T                             | D EE BALANCED                                       | *FBC         | 90         |
| C *               | N : DIMENSIO                             | N OF MATRIX A                                       | *FBC         | 100        |
| ር ፡፡<br>በ ፡፡      |                                          | NOLUN UF H<br>NTAINING INFORMATION ABOUT PERMUTATIO | *FBC         | 120        |
| Č *               | AND SCAL                                 | E FACTORS                                           | *FBC         | 130        |
| C *               | K,L : INTEGERS                           | SUCH THAT A(I, J)=0 IF (1) I GT J AND               | *FEC         | 140        |
|                   | (2) J=1,                                 | 2,,K-1 07 I=L+1,,N                                  | *FBC<br>*FBC | 150        |
| し **<br>「新教教会会会会会 | *******                                  | 끟갆슻끟챓숺숺슻놰븮숺??????????????????????????????????       | *FBC         | 170        |
| č                 |                                          |                                                     | FEC          | 180        |
| DI                | 1ENSION A(IA,1), D(1)                    |                                                     | FBC          | 190        |
| EA                | (A 8/16.0/)D2/253.0/                     | 97.4                                                | FBC          | 200        |
| E En              | 14 2ER0/0.0/3012/1.0/3/502/              |                                                     | FDC          | 220        |
| C******           |                                          | REDUCE NORM A BY DIAGONAL SIMILARITY                | FEC          | 230        |
| Casaasaa<br>      |                                          | TRANSFORMATION STORED IN D                          | FBC          | 240        |
| U 11.             | - 1                                      |                                                     | FBC          | 220        |
| K1:               | - <u>-</u><br>=N                         |                                                     | FBC          | 270        |
| C                 |                                          |                                                     | FEC          | 580        |
| C******           |                                          | SEARCH FOR ROWS ISOLATING AN EIGEN-                 | FBC          | 500<br>580 |
| [~*******         |                                          | CHEUS HIMD MOSA THEN DUWN                           | FBC          | 310        |
| 101 K1            | ° <u>1</u> =K <u>1+1</u>                 |                                                     | FBC          | 320        |
| 17                | (K1.LT.1) GD TD 107                      |                                                     | FEC          | 330        |
| K1                | L=K1<br>105    =1  K11                   |                                                     | FBC          | 250        |
| <i>D</i> O        | J=K1P1-JJ                                |                                                     | FBC          | 360        |
|                   | R=ZERO                                   |                                                     | FBC          | 370        |
|                   | DO 102 I=1,K1                            |                                                     | FBC          | 380        |
|                   | 17 (1.10.J) 60 (0.102<br>P=2+0BS(0(1.1)) |                                                     | FBC          | 400        |
| 102               | CONTINUE                                 |                                                     | FBC          | 410        |
|                   | IF (R.NE.ZERO) GO TO 106                 |                                                     | FBC          | 420        |
|                   |                                          |                                                     | FBC          | 430        |
|                   | nn 103 7=1.K1                            |                                                     | FBC          | 450        |
|                   | F=A(I,J)                                 |                                                     | FEC          | 460        |
|                   | A(I,J)=A(I,K1)                           |                                                     | FEC          | 470        |
| 107               |                                          |                                                     | FEC          | 480        |
| 105               | DO 104 I=L1.N                            |                                                     | FBC          | 500        |
|                   | F=A(J,1)                                 |                                                     | FBC          | 510        |
|                   | ∩(J,I)=A(K1,I)                           |                                                     | F BC         | 520        |
| 104               |                                          |                                                     | FEC          | 540        |
| 105               | K1=K1-1                                  |                                                     | FBC          | 550        |
| -                 | GO TO 101                                |                                                     | FBC          | 560        |
| _ 10G CO          | TINUE                                    |                                                     | FEC          | 570        |
| し<br>【教授公会教徒      |                                          | SEARCH FOR COLUMNS ISOLATING AN                     | FBC          | 590        |
| Casessa           |                                          | EIGENVALUE AND PUSH THEM LEFT                       | FBC          | 600        |

FIC 610 C FEC 107 IF (1.LT.L1) GO TO 113 620 630 LL=L1 DO 112 J=LL,K1 FDC G40 C=ZERO 650 FEC CS0 DO 108 I=L1.K1 IF (I.EO.J) GO TO 108 FDC G70 FDC 620 C=C+ABS(A(I,J))620 108 CONTINUE FDC IF (C.NE.ZERO) GO TO 112 700 FDC D(L1)=J 710 IF (J.ĒQ.L1) GO TO 111 720 FEC 730 DO 109 I=1,K1 740 F=A(1,J) FBC FDC FDC FDC FDC FDC FDC 750 A(I,J)=A(I,L1)7C0 A(I,L1)=F 109 CONTINUE 770 780 DO 110 I=L1.N 720 F=A(J,I)800 A(J,I)=A(L1,I)FDC 810 A(L1,I)=F FDC FDC FDC FDC 620 110 CONTINUE 023 L1=L1+1 111 840 GO TO 107 112 CONTINUE 850 FDC FDC FDC **E**S0 С NOW BALANCE THE SUBMATRIX IN ROWS 870 C\*\*\*\* L1 THROUGH K1 880 [\*\*\*\*\*\* FEC 800 С FEC 500 510 113 K=L1 L=K1 FDC FDC 530 IF (K1.LT.L1) GD TO 115 530 DO 114 I=L1.K1 FEC 540 D(I)=ONE FDC FDC FDC 230 114 CONTINUE 230 115 NOCONU=0 IF (K1.LT.L1) GO TO 124 DO 123 I=L1,K1 C≈ZERO \$70 520 FDC 550 FEC 250 FEC 1000 FEC 1010 R=ZERO DO 116 J=L1,K1 IF (J.EO.I) GO TO 116 FDC 1020 FEC 1030 C=C+ABS(A(J,I))FEC 1040 FEC 1050 R=R+ABS(A(I,J)) 116 CONTINUE FLC 1050 FDC 1070 G≈R⁄B F=ONE FDC 1080 S≈C+R FDC 1080 FDC 1080 FDC 1100 FDC 1100 FDC 1120 FDC 1120 FDC 1120 FDC 1150 IF (C.GE.G) GO TO 118 117 F=F\*B C=C\*E2 GO TO 117 G=R≉B 118 IF (C.LT.G) GO TO 120 F=F/B 119 FDC 1160 FDC 1170 C=C/B2 GO TO 119 FTC 1180 FTC 1180 С NOW BALANCE C\*\*\*\*\* C FDC 1200

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|         | 120         | IF ((C+R)/F.GE.P95*S) GO TO 123                         | FBC          | 1210           |
|---------|-------------|---------------------------------------------------------|--------------|----------------|
|         |             | G≈UNL/r<br>DCIN=BCIN#E                                  | 150          | 1220           |
|         |             | NUCUVIC: 1                                              | 7 DL<br>F EC | 1240           |
|         |             |                                                         | FBC          | 1250           |
|         |             | A(1, J) = A(1, J) * G                                   | FEC          | 1250           |
|         | 121         | CONTINUE                                                | FDC          | 1270           |
|         |             | DD 122 J=1,K1                                           | FBC          | 1280           |
|         |             | A(J,I)≈A(J,I)*F                                         | FEC          | 1290           |
|         | 155         | CONTINUE                                                | FBC          | 1300           |
|         | 153         | CONTINUE                                                | FBC          | 1310           |
|         | 124         | IF (NOCONV.ED.1) GO TO 115                              | FBC          | 1350           |
| _       |             | RETURN                                                  | FEC          | 1330           |
| С       |             |                                                         | FBC          | 1340           |
|         |             |                                                         | 150          | 1350           |
| c       |             | SUBKUUTTHE PEVEN (H, H, H, W, Z, WK, TEK)               | FEU          | 20             |
| с.      | 101-16-25-2 | <b>这边就没有这边是这些这些这些这些这些是这些这些这些这些这些这些这些这些这些这些是是是是是是是是</b>  | FEV.         | 20             |
| č       |             | ×                                                       | *FEU         | 40             |
| č*      | ***         | ** THIS SUB-PROGRAM PERFORMS THE FOULDWING FUNCTION:    | *FEU         | 50             |
| č       |             | * 1. ACT AS THE EXECUTIVE CALLING PROGRAM FOR OBTAINING | #FEU         | 60             |
| Ĉ       |             | * THE EIGENVALUES-EIGENVECTORS OF A REAL MATRIX.        | *FEU         | 70             |
| С       |             | 4                                                       | <b>≮</b> FEU | 80             |
| C×      | 公父★4        | ** THIS SUB-FROGRAM USES THE FOLLOWING SUBROUTINES:     | *FEU         | S0             |
| С       |             | * 1. FBALNC                                             | *FEU         | 100            |
| C       |             | * 2. FRDH33                                             | *FEU         | 110            |
| 5       |             | * 3. FEKXM1                                             | *FEU         | 150            |
| C       |             | * 4. FEXXIC2                                            | *FEU         | 130            |
| Ľ,      |             |                                                         | *rEU         | 140            |
| Ľ       |             | * 5. FEKISI                                             | ******       | 100            |
| с<br>Гя | 3488        | THIS SUR-DODODOMAS OF CONTRAN NAMES:                    | *FEU         | 170            |
| ř       |             | * A : MATRIX NUMBE FIGENUAL DES-FIGENUECTORS ARE T      |              | 180            |
| č       |             | * 70 BF FOUND                                           | *FEU         | 120            |
| č       |             | * N : DIMENSION OF MATRIX A                             | *FEU         | 200            |
| Ĉ       |             | * IA : ROW DIMENSION OF A                               | *FEV         | 210            |
| С       |             | * U : ARRAY CONTAINING THE EIGENALUES                   | *FEU         | 220            |
| С       |             | * Z : NODAL MATRIX                                      | *FEU         | 530            |
| С       |             | * NCK : NORK ARRAY                                      | *FEU         | 240            |
| C .     |             | * IER : ERROR PARAMETER                                 | *FEU         | 250            |
| Č.      |             | *                                                       | *FEU         | 260            |
| C*      | ***         | 놂 <b>꾞</b> 쎫큟슻슻븮슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻      |              | 200            |
| L       |             | DIMENCION ACTA 11 HOLD HEALTH 2(1)                      | FEU          | 290            |
|         |             |                                                         | FFŬ          | 300            |
| r       |             |                                                         | FEU          | 310            |
| Č*      | ***         | INITIALIZE ERROR PARAMETERS                             | FEU          | 320            |
| č       |             |                                                         | FEU          | 330            |
| -       |             | IER=0                                                   | FEU          | 340            |
|         |             | JER=0                                                   | FEV          | 350            |
|         |             | IZAIA                                                   | FEV          | 360            |
|         |             | 122=12+12                                               | FEU          | 370            |
| Ũ.      |             |                                                         | FEU          | 380            |
| C a     | ***         | PACK A INIU AN A BY A HKKAY                             | FEU          | - 390<br>- 200 |
| L       |             |                                                         | 111          | 210            |
|         |             |                                                         | FEU          | 420            |
|         |             | DR 105 .1=1.N                                           | FFU          | 430            |
|         |             | no 105 T=1.N                                            | FEŬ          | 440            |
|         |             | $\Theta(K,L) = A(I,J)$                                  | FEU          | 450            |
|         |             |                                                         |              | •              |

K=K+1 IF (K.GT.IA) K=1 IF (K.EQ.1) L=L+1 FEU 460 FEU 470 FEU 480 105 CONTINUE FEU 490 N1=1 500 FEU N2=N1+1 FEU 510 С FEU 520 BALANCE THE INPUT A C\* FEV 530 С FEU 540 CALL FBALNC (A, N, N, WK(1, N1), K, L) FEU 550 С FEU 560 C\*\*\*\* IF L = 0, A IS ALREADY IN HESSENBERG 570 FEU C\*\*\*\*\* FORM FEU 580 С FEU 590 CALL FRDHSS (A.K.L.N.N.WK(1.N2)) FEU 600 С FEU 610 Ĉ, SET Z IDENTITY MATRIX 650 FEU Ĉ FEU 630 II=1 FEV 640 . 1. 1= 1 FEU 650 NP1=N+1 FEU 660 DO 115 I=1.N FEU 670 DO 110 J=1,N Z(II)=ZERO FEU 680 FEU 690 II=II+1 FEU 7'00 110 CONTINUE FEV FEV 710 Z(JJ)=ONE 720 JJ=JJ+NP1 FEU 730 115 CONTINUE FEU 740 CALL FBKXM1 (Z,A,WK(1,N2),N,N,K,L)FEU 750 IIZ=N FEU 760 CALL FORALG (A,N,N,K,L,W(1),W(N+1),Z,IIZ,JER) IF (JER.GT.128) GO TO 120 CALL FBKXM2 (WK(1,N1),Z,K,L,N,N,N) FEU 770 780 FEU FEU 790 С 800 FEU CONVERT W (EIGENVALUES) TO COMPLEX C\*\*\*\*\* FEU 810 C\*\*\*\*\* FORMAT FEU 820 FEU 830 С 120 DO 125 I=1.N FEU 840 NPI=N+I FEV 850 WK(I,N1)=W(NPI) FEU 860 125 CONTINUE FEU 870 880 N+N=WL FEU J=N FEU 2003 DO 130 I=1.N FEU 200 W(JW-1)=W(J)FEU 910 W(JW) = WK(J, NI)FEU 220 FEU 930 2-MC=MC J=J-1 130 CONTINUE FEU S40 250 FFU 260 С FEV CONVERT Z (EIGENVECTORS) TO COMPLEX C\*\*\*\*\* FEU S70 C\*\*\*\*\* FORMAT Z(IZ,N) FEU 280 FEU 290 С J=N FEU 1000 135 IF (J.LT.1) GO TO 160 IF (W(J+J).EQ.ZERO) GO TO 150 FEU 1010 FEU 1020 С FEV 1030 MOVE PAIR OF COMPLEX CONJUGATE FEU 1040 C\* EIGENVECTORS FEU 1050 C\*\*\*\*\*

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С FEU 1060 IS=IZ2\*(J-1)+1 FEU 1070 IG=N\*(J-2)+1 FEV 1080 FEU 1090 IGZ≈IG+N С FEU 1100 FEU 1110 С\* С MOVE COMPLEX CONJUGATE EIGENVECTOR FEV 1120 DO 140 I=1,N FEV 1130 Z(IS)=Z(IG) FEU 1140 Z(IS+1)=-Z(IGZ) FEU 1150 IS=IS+2 FEU 1160 FEU 1170 FEU 1180 IG=IG+1 IGZ=IGZ+1 140 CONTINUE FEU 1190 С FEV 1200 **[#**##### MOVE COMPLEX EIGENVECTOR FEV 1210 Ċ FEU 1220 IS=IZ2\*(J-2)+1 FEU 1230 IG=15+122 FEU 1240 FEU 1250 DD 145 I=1,N Z(IS)=Z(IG) FEV 1260 2(IS+1)=-2(IG+1) FEU 1270 IS≃IS+2 FEU 1280 IC=IC+2 FEU 1290 145 CONTINUE FEU 1300 FEU 1310 FEU 1320 J=J-2 GO TO 135 C C\*\*\*\*\*\* FEU 1330 FEU 1340 MOVE REAL EIGENVECTOR FEV 1350 С 150 IS=IZ2\*(J-1)+N+N FEV 1360 IG=N\*J FEV 1370 DO 155 I=1,N FEU 1380 Z(IS-1)=Z(IG)FEV 1390 FEU 1400 Z(IS)=ZERO FEV 1410 IS=IS-2 FEU 1420 IG=IG-1 155 CONTINUE FEU 1430 J=J−1 FEU 1440 GO TO 135 FEV 1450 FEV 1460 C C\*\*\*\*\*\*WRITE ERROR MESSAGES, IF ANY FEU 1470 FEU 1480 С 160 IF (IER.NE.O) CALL FERTST (IER.GHFEVEV ) IF (JER.E0.0) GO TO 165 FEU 1490 FEV 1500 IER=JER FEV 1510 FEU 1520 CALL FERTST (IER, GHFEVEV ) 165 RETURN FEU 1530 С FEU 1540 FEU 1550 END SUBROUTINE FEXXM1 (Z, H, D, MM, IZH, K, L) FM1 10 C FM1 20 C\* ##FM1 30 С # \*FM1 40 THIS SUB-PROGRAM PERFORMS THE FOLLOWING FUNCTION: \*FM1 1. DACKTRANSFORM THE EIGENVECTORS OF THE UPPER HESSENBERG\*FM1 50 C\*\*\*\*\*\* С # 60 Ĉ MATRIX. #FM1 70 ÷ č \*FM1 80 THIS SUB-PROGRAMZS GLOSSARY OF FORTRAN NAMES: #FM1 90 C###### : EIGENVECTORS OF MATRIX A #FM1 100 C ÷ Z

States States C.

| С      |      | * H : SUB-DIAGONAL ELEMENTS USED FOR STORING BACK-                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | *FM1                                   | 110        |
|--------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|------------|
| С      |      | <ul> <li>TRANSFORMATION INFORMATION</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | *7111                                  | 120        |
| С      |      | D : DETAILS OF THE TRANSFORMATION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | *FM1                                   | 130        |
| С      |      | MM : NUMBER OF COLUMNS IN MATRIX Z                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | *Fm1                                   | 140        |
| С      |      | IZH : ROW DIMENSION OF MATRICES Z AND H                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | *FM1                                   | 150        |
| С      |      | K,L : SAME AS IN SUBROUTINE FBKXM1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | *FM1                                   | 160        |
| С      |      | ¥                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | *FM1                                   | 170        |
| CI     | **** | <b>著学者者主要者者者者的父亲教会的弟弟我以父父弟弟弟父父弟弟弟父父父弟弟弟父父子弟子弟子父弟父弟弟弟弟弟弟弟弟弟妻妻妻妻妻妻妻妻</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | •*FM1                                  | 180        |
| С      |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | FM1                                    | 150        |
|        |      | DIMENSION Z(IZH, 1), H(IZH, 1), D(1)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | FM1                                    | 200        |
|        |      | DATA_ZERO, ONE/0.0, 1.0/                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | FM1                                    | 210        |
|        |      | LM2=L-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | FM1                                    | 220        |
|        |      | IF (LM2.LI.K) GO TO 107                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | FM1                                    | 230        |
|        |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 1.571                                  | 240        |
|        |      | DU 105 KI=K,LM2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | FM1                                    | 250        |
|        |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | F EL                                   | 250        |
|        |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 1111                                   | 270        |
|        |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 1° 1° 1 4.<br>1754 4                   | 200        |
|        |      | IF (I.EU.ZERU) GU IU IUS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 17 373 ±<br>77 54 ±                    | 200        |
|        |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | P Pri L                                | 200        |
|        |      | $\frac{1}{1} = \frac{1}{1} = \frac{1}$ | EM1                                    | 210        |
|        |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | EN1                                    | 220        |
|        |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | GM1                                    | 520        |
|        | 101  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Frit                                   | 350        |
|        | 102  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | FG1                                    | 550        |
|        | IUL  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | F111                                   | 370        |
|        |      | 7. 105 J=1. MM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | FMI                                    | 280        |
|        |      | G=ZERD                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | FMI                                    | 250        |
|        |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | F111                                   | 400        |
|        |      | $G \approx G + D(1) \approx 2(1, J)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | FM1                                    | 410        |
|        | 103  | CONTINUE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | FM1                                    | 420        |
|        |      | G=G*TINU                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Fn11                                   | 420        |
|        |      | DO 104 I=MA,L                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | FH1                                    | 440        |
|        |      | Z(I,J)=Z(I,J)+G*D(I)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | FM1                                    | 450        |
|        | 104  | CONTINUE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | FM1                                    | 450        |
|        | 105  | CONTINUE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | FM1                                    | 470        |
|        | 105  | CONTINUE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | FM1                                    | 480        |
|        | 107  | RETURN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | FM1                                    | 490        |
| С      |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | FN1                                    | 500        |
|        |      | END                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | F111                                   | 510        |
| _      |      | SUBROUTINE FBXXM2 (D,2,K,L,MM,N,12)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1-112                                  | 10         |
| 5      |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 102                                    | <u>5</u> 0 |
| 5      | **** | ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | * " N'D                                | 20         |
|        |      | THIS SUD_DODODAM DEDEADMS THE SOLLOHING SUNCTION.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 11111111111111111111111111111111111111 | 40<br>110  |
| 5      | **** | ** INIS SUBFERUGRAN FERFURNS INT FULLUMING FUNCTION.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | *******<br>******                      | - 30<br>CO |
| L<br>C |      | TO DHUKIKHIDFUKN INT EIGENVILIUKS OF H DALHNULD HAIKIA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 67P2                                   | 20         |
| Ľ,     |      | THIS SUB-PROCEDMES OF OSSARY OF FORTRON NAMES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 4:EM2                                  | 50         |
| ř      |      | * D : INFORMATION ON THE DETAILS OF TRANSFORMATION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | NEMP.                                  | 50         |
| č      |      | * Z : AT ENTRANCE: MODA' MATRIX TO BE TRANSFORMED                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | *TN2                                   | 100        |
| č      |      | * AT EXIT, TRANSFORMED MODAL MATRIX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | *712                                   | 110        |
| č      |      | * K : ROW, COLUMN INDEX OF STARTING ELEMENT TO BE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | *FN2                                   | 120        |
| č      |      | + TRANSFORMED                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | *FM2                                   | 120        |
| Ĉ      |      | L : RON, COLUMN INDEX OF LAST ELEMENT TO BE TRANS-                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | -*FN2                                  | 140        |
| С      |      | • FORMED                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | *EU5                                   | 150        |
| С      |      | * MM : NUMBER OF COLUMNS IN MATRIX Z                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | *71(2                                  | 160        |
| С      |      | N : NUMBER OF ROWS IN 2 = LENGTH OF VECTOR D                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | *505                                   | 170        |
| С      |      | <ul> <li>IZ : ROW DIMENSION OF Z</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | *1115                                  | :80        |
| r      |      | •                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | REND.                                  | 100        |

| C*       | ***              | *****               | ****                                    | * 水学家家水学兴学学学家教学家教学家教学教学教学教学教学教学教学教学教学教学教学教学       | ++FM2        | 200 |
|----------|------------------|---------------------|-----------------------------------------|---------------------------------------------------|--------------|-----|
| С        |                  |                     |                                         |                                                   | FM2          | 210 |
| c        |                  | DIMENSIO            | UN Z(IZ,1), D(1)                        | )                                                 | FM2          | 220 |
| C#       | ***              | **                  |                                         | COLUMN SCALE 7 BY APPROPRIATE                     | FM2          | 240 |
| Č×       | ***              | **                  |                                         | D VALUE                                           | FM2          | 250 |
| С        |                  |                     |                                         |                                                   | FM2          | 560 |
|          |                  | DO 101 3            | E=K,L                                   |                                                   | FM2          | 270 |
|          |                  | 5≃9()<br>101 חת     | 1)<br>1-1.MM                            |                                                   | FM2          | 280 |
|          |                  | Z(1,.               | J)=Z(I,J)*S                             |                                                   | FM2          | 300 |
|          | 101              | CONTINUE            |                                         |                                                   | FM2          | 310 |
| C        |                  |                     |                                         |                                                   | FM2          | 350 |
| С*<br>Ся | ***              | **                  |                                         | INTERCHANGE ROWS IF PERMUTATIONS                  | FM2          | 330 |
| r<br>r   | ~~~              | <b>W</b> 57         |                                         | OCCORKED IN LANDIC                                | FM2          | 340 |
| 0        |                  | IF (K.EC            | 3.1) GO TO 104                          |                                                   | FM2          | 360 |
|          |                  | KM1=K-1             |                                         |                                                   | FM2          | 370 |
|          |                  | DO 103 1            | I=1,KM1                                 |                                                   | FM2          | 380 |
|          |                  | 11=K-               | -1<br>/77)                              |                                                   | F 112        | 390 |
|          |                  | 77 C                | TT.EN.UD EN TN                          | 103                                               | FM2          | 410 |
|          |                  | BO 10               | 02 J=1,MM                               | 100                                               | FM2          | 420 |
|          |                  | . S=                | =Z(II,J)                                |                                                   | FM2          | 430 |
|          |                  | 20                  | (II,J)=Z(JJ,J)                          |                                                   | FM2          | 440 |
|          | 102              |                     | (33,3)=5<br>TNUF                        |                                                   | FM2          | 450 |
|          | 103              | CONTINUS            | -                                       |                                                   | FM2          | 470 |
|          | 104              | IF (L.EC            | 3.N) GO TO 107                          |                                                   | FM2          | 480 |
|          |                  |                     | 7.7                                     |                                                   | FM2          | 490 |
|          |                  | 105 105             | 11=LP1,N<br>(TT)                        |                                                   | FM2          | 500 |
|          |                  | 16 C                | II.EO.JJ) GO TO                         | 105                                               | FM2          | 520 |
|          |                  | DO 10               | 05 J=1,MM                               |                                                   | FM2          | 530 |
|          |                  | S                   | =Z(II,J)                                |                                                   | FM2          | 540 |
|          |                  | 21                  | (II,J)=2(JJ,J)<br>(II, 1)=2             |                                                   | F M2         | 500 |
|          | 105              | נדאחם               | TNUE                                    |                                                   | FM2          | 570 |
|          | 105              | CONTINUE            | 2                                       |                                                   | FM2          | 580 |
| _        | 107              | RETURN              |                                         |                                                   | FM2          | 590 |
| С        |                  |                     |                                         |                                                   | FM2          | 600 |
|          |                  | ר גוונטפטעב<br>העום | INT FERIAT (IFP.                        | NAMEL                                             | FFR          | 10  |
| С        |                  | 569K661             |                                         |                                                   | FER          | 20  |
| C+       | ***              | ***                 | ****                                    | ***************************************           | **FER        | 30  |
| C        |                  | * THIS              | SUB-PROGRAM PER                         | RFORMS THE FOLLOWING FUNCTION:                    | *FER         | 40  |
| C<br>C   |                  | *                   | 1. PRIMI ERROR                          | MESSAGE ARISING IN FEVEN OR FORMED ROUTING        | SFER<br>SFER | 00  |
| C#       | ***              | ** THIS             | SUB-PROGRAM#S 0                         | LOSSARY OF FORTRAN NAMES:                         | *FER         | 70  |
| č        |                  | #                   | IER : ERA                               | ROR PARAMETER VALUE                               | <b>#FER</b>  | 80  |
| С        |                  | 4                   | NAME : NAM                              | 1E OF THE CALLING SUB-PROGRAM                     | *FER         | 90  |
| C<br>C   |                  | *                   | ****                                    | ******                                            |              | 100 |
| с»<br>С  | - <b>W. W. W</b> | *********           | *************************************** | ה <b>ההההה הא הא ה</b> א הא הא הא א א א א א א א א | FER          | 120 |
| 3        |                  | DIMENSIC            | DN ITYP(2,4), II                        | 317(4)                                            | FER          | 130 |
|          |                  | INTEGER             | WARN, MARF, TERM,                       | PRINTR                                            | FER          | 140 |
|          |                  | ECUIVALE            | ENCE (IBIT(1), NA                       | RRN), (IBIT(2),WARF), (IBIT(3),TERM)              | FER          | 150 |
|          |                  | 110975040           | 16/10626301116                          | .10HNON-DEFINE.10HD /.TRIT/32                     | 6FFR         | 170 |
|          | i                | 24,128,0/           | /                                       |                                                   | FER          | 180 |

1.1.2

| r         | IERR=IER<br>IF (IERR.GE.WARN) GD TO 101            |                                        | FER<br>FER<br>FER | 190<br>200<br>210 |
|-----------|----------------------------------------------------|----------------------------------------|-------------------|-------------------|
| C****     | **                                                 | NON-DEFINED                            | FER               | 550               |
| С         |                                                    |                                        | FER               | 230               |
|           | IERK=4                                             |                                        | FER               | 240               |
| 101       | GU 10 104<br>TE (TERR LT TERM) CO TO 100           |                                        | FER               | 220               |
| C 101     | IF CIERRALIATERIA GU TO TOE                        |                                        | FER               | 270               |
| Č****     | **                                                 | TERMINAL                               | FER               | 280               |
| С         |                                                    |                                        | FER               | 220               |
|           | IERK=3                                             |                                        | FER               | 200               |
| 102       | 50 10 104<br>IF (IFPR (I HARE) CO IO 103           |                                        | FER               | 310<br>720        |
| C 10E     | IF (IERR.ET.WHRF) 30 TO 103                        |                                        | FER               | 330               |
| <br>C**** | ** (                                               | WARNING(WITH FIX)                      | FER               | 340               |
| С         |                                                    |                                        | FER               | 350               |
|           | IERK=2                                             |                                        | FER               | 250               |
| r.        | GU 10 104                                          |                                        | FER               | 220               |
| C****     | **                                                 | JARNING                                | FER               | 350               |
| Ċ         |                                                    |                                        | FER               | 400               |
| _ 103     | IERK=1                                             |                                        | FER               | 410               |
|           |                                                    | CUTRACT ANA                            | ドビオ               | 420               |
| C         |                                                    |                                        | FER               | 440               |
| 104       | IERR≈IERR-IBIT(IERK)                               |                                        | FER               | 450               |
| С         |                                                    |                                        | FER               | 450               |
| C****     | **                                                 | PRINT ERROR MESSAGE                    | FER               | 470               |
| L         | URITE (6.105) (ITYP(I.TERK).I:                     | =1.21.NAME.TERR.TER                    | FER               | 450               |
|           | RETURN                                             | -IFE/FINNEFIENCFIEN                    | FER               | 500               |
| С         |                                                    |                                        | FER               | 510               |
| _ 105     | FORMAT (1H0,2A10,4X,A6,4X,I2,                      | BH (IER = ,I3,1H))                     | FER               | 520               |
| C         | CND                                                |                                        | FER               | 530               |
|           | SUBROUTINE FORALG (HS.N. TH.K.)                    | . WRI . WTM. Z. IZ. IER)               | FÜR               | 10                |
| С         |                                                    |                                        | FCR               | 50                |
| C****     | ***************************************            | 똜 <sup>슻</sup> 봕썦꾞꾞뚃쎫쁥쁥쁥쁥쁥쁥쁥쁥쎫닅슻슻섟섟섟섟슻 | **FOR             | 30                |
| C         | *<br>** THIE CUP_DOCEAM REDEARMS '                 |                                        | *F02              | 40                |
| C****     | * 1113 SOBEROGRAM PERFORMS                         | TS AND FIGENVECTORS OF THE UPPER       | *FOR              | 60                |
| č         | + HESSENBERG MATRIX.                               |                                        | *FOR              | 70                |
| C         | *                                                  |                                        | *FCR              | 03                |
| C****     | ** THIS SUB-PROGRAM USES THE P                     | LOFTOMING SORKOOLINE:                  | *** UK            | 100               |
| с<br>С    | - 1. FEK(3)                                        |                                        | *505              | 110               |
| C****     | ** THIS SUB-PROGRAM≠S GLOSSAR'                     | Y OF FORTRAN NAMES:                    | *FOR              | 120               |
| Č         | * ALL VARIABLE NAMES AND ARRA                      | AYS ARE AS DEFINED IN SUBROUTINES      | *702              | 130               |
| ç         | <ul> <li>FEVEV, FBALNC, FBKXM1, FBKXM2.</li> </ul> | •                                      | *FOR              | 140               |
| Casas     | ***************************************            | *****                                  | **UK<br>##200     | 150               |
| C         | ***************************************            |                                        | FCR               | 170               |
| -         | DIMENSION HS(IH,N), WRL(N), W                      | IM(N), Z(IZ,N), T3(2)                  | FOR               | 180               |
|           | LOGICAL NTLS                                       |                                        | FCR               | 190               |
|           | COMPLEX Z3                                         |                                        | FCR               | 200               |
|           | TOTO PREI P/164140000000000000                     | 008/                                   | FOR               | 220               |
|           | DATA P4/0.4375/,P5/0.5/,P7/0.1                     | 75/, ZERO/0.0/, ONE/1.0/               | FER               | 230               |
|           | IER=0                                              |                                        | FCR               | 240               |

| C<br>C        | **** | **                                                          | STORE ROOTS ISOLATED BY FBAUNC                | FOR                      | 250                      |
|---------------|------|-------------------------------------------------------------|-----------------------------------------------|--------------------------|--------------------------|
| L             |      | DO 101 I=1,N<br>IF (I.GE.K.AND.I.LE.L) GO<br>WRL(I)=HS(I,I) | ТО 101                                        | FOR<br>FOR<br>FOR<br>FOR | 270<br>280<br>290<br>300 |
|               | 101  | NIM(I)=ZERO<br>CONTINUE<br>IEN=L<br>T=ZERO                  |                                               | FOR<br>FOR<br>FOR<br>FOR | 310<br>320<br>330<br>340 |
| C             |      |                                                             |                                               | FOR                      | 350                      |
| C             | **** | **                                                          | SEARCH FUR NEXT EIGENOALDES                   | FOR                      | 370                      |
|               | 102  | IF (IEN.LT.K) GO TO 128<br>ITS=0<br>NA=IEN-1<br>IFNM9=NA-1  |                                               | FOR<br>FOR<br>FOR<br>FOR | 380<br>390<br>400<br>410 |
| C             |      |                                                             |                                               | FOR                      | 420                      |
| C*<br>C*<br>C | **** | 体 34<br>关 34                                                | LOOK FOR SINGLE SMALL SUB-DIAGONAL<br>ELEMENT | FOR<br>FOR<br>FOR        | 430<br>440<br>450        |
|               | 103  | NPL=IEN+K                                                   |                                               | FCR                      | 460                      |
|               |      | LB=NPL-LL                                                   |                                               | FCR                      | 480                      |
|               |      | IF (LB.EQ.K) GO TO 105                                      |                                               | FOR                      | 490                      |
|               | 1    | 1 ))) GO TO 105                                             |                                               | FOR                      | 510                      |
| ~             | 104  | CONTINUE                                                    |                                               | FOR                      | 520                      |
| с;            | **** | **                                                          |                                               | FOR                      | 540                      |
| С             |      |                                                             |                                               | FOR                      | 550                      |
|               | 105  | X=H5(1EN,1EN)<br>TE (LB.EA.TEN) CO TO 121                   |                                               | FOR                      | 550<br>570               |
|               |      | Y=HS(NA,NA)                                                 |                                               | FOR                      | 580                      |
|               |      | U≈HS(IEN,NA)≉HS(NA,IEN)<br>IE (LB EQ NA) CO TO 122          |                                               | FOR                      | 590<br>600               |
|               |      | IF (ITS.E0.30) GO TO 151                                    |                                               | FCR                      | 610                      |
| 2             |      | **                                                          | CHOM CHIET                                    | FQR                      | 620                      |
| C             |      | * *                                                         |                                               | FOR                      | 640                      |
|               |      | IF (ITS.NE.10.AND.ITS.NE.20)                                | GO TO 107                                     | FQR                      | 650                      |
|               |      | DD 103 I=K, IEN                                             |                                               | FOR                      | 670                      |
|               |      | HS(I,I)=HS(I,I)-X                                           |                                               | FOR                      | 680                      |
|               | 105  | CONTINUE<br>SEARS(HS(IEN.NA))+ARS(HS(NA.)                   | TENMOL                                        | FOR                      | 700                      |
|               |      | X=P7*S                                                      | م × عدا ۱۱ امر ک                              | FOR                      | 710                      |
|               |      | Y=X<br>H==D4#CaC                                            |                                               | FOR                      | 720                      |
|               | 107  | 1TS=1TS+1                                                   |                                               | FCR                      | 740                      |
| C             |      |                                                             | LOOK COD THE CONSECUTIVE SMOLL                | FOR                      | 750                      |
|               | **** | · · · · · · · · · · · · · · · · · · ·                       | SUB-DIAGONAL ELEMENTS                         | FOR                      | 770                      |
| ĉ             |      |                                                             |                                               | FOR                      | 780                      |
|               |      | NAML=IENM2+LB<br>DO 103 MM=! B. IENM2                       |                                               | FOR                      | -780<br>-800             |
|               |      |                                                             |                                               | FOR                      | 810                      |
|               |      | 22=H3(M,M)                                                  |                                               | FOR                      | 820                      |
|               |      | パーパームと                                                      |                                               | FOR                      | 840                      |

|    |       |      | P=(R*S-W)/H3(M+1,M)+H5(M,M+1)<br>Q=H5(M+1,M+1)-72-R-5                        | FCR        | 850<br>860      |
|----|-------|------|------------------------------------------------------------------------------|------------|-----------------|
|    |       |      | R=H5(N+2,N+1)                                                                | FER        | 870             |
|    |       |      | S=ABS(P)+ABS(Q)+ABS(R)                                                       | FCR        | 603             |
|    |       |      | P=P/S                                                                        | FCR        | 820             |
|    |       |      | Q=0/S                                                                        | FCR        | 500             |
|    |       |      | R=R/S                                                                        | FER        | $\epsilon_{10}$ |
|    |       |      | IF (M.EQ.LB) GO TO 109                                                       | F.C.K      | 530             |
|    |       |      | <pre>IF (ABS(HS(M,N-1))*(ABS(Q)+ABS(R)).LE.RDELP*A3S(P)*(ABS(HS(M-1)))</pre> | FCR        | 530             |
|    |       | 1    | H-1))+ABS(Z2)+AES(HS(M+1,M+1)))) GD TD 109                                   | FER        | 540             |
|    | 108   | CON  |                                                                              | FER.       | 550             |
|    | 109   | FIF2 |                                                                              | T L'R      | 250             |
|    |       | ыu   | 110 ISANCATAN<br>Mart 1-01-7700                                              | FLK<br>CCD | - 270<br>- 690  |
|    |       |      | TE (I ED M22) DD 70 110                                                      | 100        | - COU           |
|    |       |      | HS(1,1-3)=7FPD                                                               | 100        | 1000            |
|    | 110   | CON  | NTINUE                                                                       | FCR        | 1010            |
| ε  |       | 00.  |                                                                              | FER        | 1020            |
| Ĉ* | ****  | * *  | DOUBLE OR STEP INVOLVING ROWS                                                | FCR        | 1030            |
| C* | ***   | ¥ ¥  | L TO EN AND COLUMNS M TO EN                                                  | FOR        | 1040            |
| С  |       |      |                                                                              | FCR        | 1050            |
|    |       | DO   | 120 KA=M.NA                                                                  | ECS        | 1030            |
|    |       |      | NTLS=KA.NE.NA                                                                | FCR        | 1070            |
|    |       |      | IF (KA.20.M) GO TO 111                                                       | FLR        | 1620            |
|    |       |      |                                                                              | TCS        | 1100            |
|    |       |      | U=H3(KH+1,KH-1)                                                              | 500        | 1100            |
|    |       |      | K-4EKU<br>TE (NTES) R-49(KA+2,KA+1)                                          | 500        | 1120            |
|    |       |      | Y=6RS(P)+6RS(0)+6RS(P)                                                       | FED        | 1120            |
|    |       |      | TE (X.ED.ZERD) CO TO 120                                                     | FER        | 1120            |
|    |       |      |                                                                              | FCR        | 1150            |
|    |       |      |                                                                              | FCR        | 1160            |
|    |       |      | R=R/X                                                                        | FCR        | 2170            |
|    | 111   |      | CONTINUE                                                                     | FC2        | 1180            |
|    |       |      | S=SIGN(SORT(P*P+O*O+R*R),P)                                                  | FCR        | 1120            |
|    |       |      | IF (KA.EO.M) GO TO 112                                                       | FCR        | 1200            |
|    |       |      | HS(KA,KA-1)=-S*X                                                             | FUR.       | 1510            |
|    |       |      |                                                                              | FUR        | 1620            |
|    | 112   |      | 1r (LB.NE.N) HO(KH,KH-1)==HO(KH,KH-1)                                        | CC2        | 1220            |
|    | 112   |      |                                                                              | FDD        | 1250            |
|    |       |      | Y=0/S                                                                        | FER        | 1230            |
|    |       |      | 72=R/S                                                                       | FCR        | 1270            |
|    |       |      | 0=0/P                                                                        | FER        | 1230            |
|    |       |      | R=R/P                                                                        | FER        | 1220            |
| С  |       |      |                                                                              | FCR        | 1300            |
| C* | ***   | **   | ROW MODIFICATION                                                             | FCR        | 1210            |
| С  |       |      |                                                                              | 1.6%       | 1320            |
|    |       |      | DO 115 J=KA, N                                                               | 102        | 1230            |
|    |       |      | PERS(KA,J)+U*AS(KA+1,J)                                                      | 1.6%       | 1290            |
|    |       |      | IF (.NUT.NT.37 60 TO 114<br>D-2-08409(MA+2, 1)                               | FED        | 1220            |
|    |       |      | HS(K642, 1)=43(K642, 1)=P\$77                                                | FER        | 1020            |
|    | 114   |      |                                                                              | 502        | 1000            |
|    | ња «Т |      | HS(KA, J)=HS(KA, J)=P*X                                                      | I.C.S      | 1320            |
|    | 115   |      | CONTINUE                                                                     | FER        | 1400            |
|    |       |      | J=#11NO(IEN,KA+3)                                                            | FOR        | 1410            |
| С  |       |      |                                                                              | FCR        | 1420            |
| C۹ | ***   | **   | COLUMN MODIFICATION                                                          | FCR        | 1430            |
| C  |       |      |                                                                              | 102        | -1440           |

|         | 116<br>117 |                  | 117 I=1,J<br>P=X*H5(I,KA)+Y*H5(I,KA<br>IF (.NDT.NTLS) G0 TO 1<br>P=P+ZZ*H5(I,KA+2)<br>H5(I,KA+2)=H3(I,KA+2)-<br>H5(I,KA)=H3(I,KA+1)-<br>H3(I,KA)=H5(I,KA)-P<br>NTINUE<br>(IZ.LT.N) GD TO 120 | +1)<br>15<br>P*2<br>P≈0    | FOR<br>FOR<br>FOR<br>FOR<br>FOR<br>FOR<br>FOR<br>FOR<br>FOR<br>FOR | 1450<br>1460<br>1470<br>1480<br>1490<br>1500<br>1510<br>1520<br>1530 |
|---------|------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|--------------------------------------------------------------------|----------------------------------------------------------------------|
| C<br>∩≉ |            | *                |                                                                                                                                                                                              | ACCUMULATE TRANSFORMATIONS | FOR                                                                | 1550                                                                 |
| C       |            | ר<br>חח          | 119 T=K.L                                                                                                                                                                                    |                            | FOR<br>FOR                                                         | 15S0<br>1570                                                         |
|         | 110        |                  | P=X*Z(I,KA)+Y*Z(I,KA+1<br>IF (.NOT.NTLS) G0 TO 1<br>P=P+ZZ*Z(I,KA+2)<br>Z(I,KA+2)=Z(I,KA+2)-P*                                                                                               | )<br>13<br>R               | FOR<br>FOR<br>FOR<br>FOR<br>FOR                                    | 1580<br>1590<br>1600<br>1610<br>1620                                 |
|         | 113        |                  | Z(I,KA)=Z(I,KA)-P                                                                                                                                                                            |                            | FOR                                                                | 1630                                                                 |
|         | 119        | CO               | NTINUE                                                                                                                                                                                       |                            | FOR                                                                | 1640<br>1650                                                         |
|         | 150        | CUNIL            | 103                                                                                                                                                                                          |                            | FOR                                                                | 1650                                                                 |
| С       |            | 00 10            | 200                                                                                                                                                                                          |                            | FOR                                                                | 1670                                                                 |
| C*      | *****      | + <del>3</del> + |                                                                                                                                                                                              | NUT KOOT LOOND             | FOR                                                                | 1690                                                                 |
| L       | 121        | HS(IE            | N, IEN)=X+T                                                                                                                                                                                  |                            | FOR                                                                | 1700                                                                 |
|         |            | NSF (I           | EN)=HS(IEN,IEN)                                                                                                                                                                              |                            | FOR                                                                | 1720                                                                 |
|         |            | WINCI<br>TEN=N   | SU)≈ZERO<br>O                                                                                                                                                                                |                            | FOR                                                                | 1730                                                                 |
|         |            | GO TO            | 102                                                                                                                                                                                          |                            | FCR                                                                | 1740                                                                 |
| C       |            |                  |                                                                                                                                                                                              |                            | FCR                                                                | 1760                                                                 |
| ເຈ<br>ເ | *****      | **               |                                                                                                                                                                                              |                            | FCR                                                                | 1770                                                                 |
| Č       | 122        | P=(Y-            | X)*P5                                                                                                                                                                                        |                            | FCR                                                                | 1780                                                                 |
|         |            | 0=7*7            |                                                                                                                                                                                              |                            | FOR                                                                | 1800                                                                 |
|         |            | 22=50<br>HS(TE   | N,IEN)=X+T                                                                                                                                                                                   |                            | FOR                                                                | 1810                                                                 |
|         |            | X=H3             | IEN, IEN)                                                                                                                                                                                    |                            | FOR                                                                | 1820                                                                 |
|         |            | HEINP            | 6 MA)=Y+T                                                                                                                                                                                    |                            | FOR                                                                | 1840                                                                 |
| c       |            | 17 (1)           | LI ZERUJ GU TU IES                                                                                                                                                                           |                            | FOR                                                                | 1850                                                                 |
| Č,      | ****       | **               |                                                                                                                                                                                              | REAL PAIR                  | FDR                                                                | 1850                                                                 |
| С       |            | 77-24            | SIGN(77.P)                                                                                                                                                                                   |                            | FOR                                                                | 1680                                                                 |
|         |            |                  | 3167(227)<br> A)=X+22<br> EN)=WRL(NA)<br>22 N=.27RA) WR!(TEN)=X-1                                                                                                                            | 1/ZZ                       | FOR<br>FOR<br>FOR                                                  | 1890<br>1900<br>1910                                                 |
|         |            | WINCH<br>WINCH   | IA)=ZERO<br>IEN)=ZERO<br>IEN,NA)                                                                                                                                                             |                            | FOR<br>FOR<br>FOR                                                  | 1920<br>1930<br>1940                                                 |
|         |            | R=SQA            | ?7(X*X+ZZ*ZZ)                                                                                                                                                                                |                            | FUR                                                                | 1550                                                                 |
|         |            | 0=ZZ/            | N. A.                                                                                                                                                    |                            | FDR                                                                | 1970                                                                 |
| C       |            |                  |                                                                                                                                                                                              | PON MODIFICATION           | FCR                                                                | 1530                                                                 |
| С<br>С  | ****       | **               |                                                                                                                                                                                              |                            | FOR                                                                | 2000                                                                 |
| 0       |            | DO 12            | 3 J=NA.N                                                                                                                                                                                     |                            | - FUR<br>503                                                       | 2020                                                                 |
|         |            | Z                | 2=H5(NA,J)<br>2(MA, J)0#77+P#H5(ISN, (                                                                                                                                                       | 1                          | FOR                                                                | 2030                                                                 |
|         |            | Hi<br>Hi         | S(IEN, J)=0*HS(IEN, J)-P*                                                                                                                                                                    | ZZ                         | FCR                                                                | 2040                                                                 |

| ſ      | 15   | 3 CONTINUE                                                                         |                            | FCR 2050             |
|--------|------|------------------------------------------------------------------------------------|----------------------------|----------------------|
| č      | ***  | ***                                                                                | COLUMN MODIFICATION        | FOR 2050             |
| C      |      | DD 124 T-1. TEN                                                                    |                            | FOR 2080             |
|        |      | ZZ = HS(1, NA)                                                                     |                            | FOR 2090             |
|        |      | HS(I, NA)=0*ZZ+P*HS(I, IEN                                                         | )                          | FCR 2100             |
|        |      | HS(I, IEN)=Q*HS(I, IEN)-P*                                                         | 22                         |                      |
|        | 124  | TE (IZ LT N) CO TO LOZ                                                             |                            | FQR 2130             |
| С      |      | IF (12.01.0) 60 10 127                                                             |                            | FOR 2140             |
| č      | **** | ***                                                                                | ACCUMULATE TRANSFORMATIONS | FCR 2150             |
| С      |      | _                                                                                  |                            | FC2 2120             |
|        |      | DO 125 I=K,L                                                                       |                            | FOR 2180             |
|        |      | 22=2(1,NA)<br>2(1,NA)=0+22+0+2(1,ICN)                                              |                            | FCR 2190             |
|        |      | Z(1, IFN) = 0 + 2(1, IFN) = 0 + 27 |                            | FCR 2200             |
|        | 125  | CONTINUE                                                                           |                            | FCR 2210             |
| _      |      | GO TO 127                                                                          |                            | FOR 2220             |
| C<br>C |      | **                                                                                 |                            | FOR 2240             |
| E.     |      | **                                                                                 | COMPLEX PAIR               | FCR 2250             |
| -      | 126  | WRL(NA)=X+P                                                                        |                            | FCR 2250             |
|        |      | WRL(IEN)=X+P                                                                       |                            | FOR 2280             |
|        |      | WIM(NA)=ZZ                                                                         |                            | FCR 2290             |
|        | 127  |                                                                                    |                            | FCR 2300             |
|        | *    | GO TO 102                                                                          |                            | FOR 2310             |
| С      |      |                                                                                    |                            | FUX 2520             |
| C1     | **** |                                                                                    | ALL ROOTS FOUND, NOW       | FER 2340             |
| E.     | **** | **                                                                                 | BACKSUBSTITUTE             | FCR 2350             |
| -      | 128  | IF (IZ.LT.N) GO TO 156                                                             |                            | FCR 2360             |
|        |      | RNORM=ZERO                                                                         |                            | FDR 2380             |
|        |      | KA=1<br>DO 130 I-1 N                                                               |                            | FCR 2390             |
|        |      | DO 129 J=KA.N                                                                      |                            | FCR 2400             |
|        |      | RNDRM=RNORM+ABS(HS(I,J                                                             | ))                         | FCR 2410             |
|        | 129  | CONTINUE                                                                           |                            | FCR 2430             |
|        | 130  |                                                                                    |                            | FCR 2440             |
|        | 150  | IF (RNORM.EQ.ZERO) GO TO 156                                                       |                            | FCR 2450             |
|        |      | DO 145 NN=1.N                                                                      |                            | FCR 2460<br>FCR 2420 |
|        |      |                                                                                    |                            | FOR 2480             |
|        |      | P=WKL(IEN)<br>D=UIM(IEN)                                                           |                            | FOR 2490             |
|        |      | NA=IEN-1                                                                           |                            | FOR 2500             |
|        |      | IF (0.GT.ZERO) GO TO 145                                                           |                            | FCR 2510             |
| ~      |      | IF (O.LT.ZERO) GO TO 137                                                           |                            | FOR 2530             |
| -<br>* | **** |                                                                                    |                            | FCR 2540             |
| 5      |      |                                                                                    | KEHL VELTUR                | FOR 2550             |
|        |      | M=IEN                                                                              |                            | FCR 2550             |
|        |      | HS(IEN, IEN)=ONE                                                                   |                            | FER 2550             |
|        |      | IF (NH.LU.U) GO TO 145<br>NO 136 IT=1-NO                                           |                            | FCR 2590             |
|        |      | I=IEN-II                                                                           |                            | FCR 2600             |
|        |      | W=HS(I,I)-P                                                                        |                            | FUR 2610             |
|        |      | R=HS(I.IEN)                                                                        |                            | FCR 2630             |
|        |      | 1F (M.GT.NA) GO TO 132                                                             |                            | FOR 2C40             |

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|              | DD 131 J=M,NA                                        | FCR 2650 |
|--------------|------------------------------------------------------|----------|
| 131          | R=R+MS(I, J)*HS(J, IEN)                              | FOR 2660 |
| 132          | IF (WIM(I).GE.ZERO) GO TO 133                        | FOR 2680 |
|              | ZZ=W                                                 | FCR 2690 |
|              | 5-x<br>GD TO 136                                     | FQR 2710 |
| 133          | M≠I                                                  | FCR 2720 |
|              | IF (WIM(I).NE.ZERD) GO TO 134<br>Tell                | FOR 2730 |
|              | IF (W.EQ.ZERO) T=RDELP*RNORM                         | FOR 2750 |
|              | HS(I, IEN)=-R/T                                      | FCR 2760 |
| с            | 60 10 135                                            | FOR 2780 |
| _<br>[****** | SOLVE REAL EQUATIONS                                 | FOR 2790 |
| C<br>134     |                                                      | FQR 2800 |
| 1.24         | Y=HS(I+1,I)                                          | FOR 2820 |
|              | D≃(WRL(I)-P)*(WRL(I)-P)+WIM(I)*WIM(I)                | FOR 2830 |
|              | HS(I, TEN)=T                                         | FOR 2850 |
|              | IF (ABS(X).LE.ABS(ZZ)) GO TO 135                     | FQR 2860 |
|              | HS(I+1,IEN)=(-R-W*T)/X                               | FOR 2870 |
| 135          | HS(I+1,IEN)=(-S-Y*T)/ZZ                              | FOR 2890 |
| 136          | CONTINUE                                             | FCR 2900 |
| [<br>[¥***** | END REAL LIFETOR                                     | FOR 5910 |
| C            |                                                      | FOR 2930 |
| ~            | CO TO 145                                            | FCR 2940 |
| L<br>[****** | LAST USCTOR COMPONENT CHOSEN                         | FOR 2550 |
| C*****       | IMAGINARY SO THAT EIGENVECTOR                        | FOR 2970 |
| [*****       | MATRIX IS TRIANGULAR                                 | FQR 2980 |
| 137          | M=NA                                                 | FOR 3000 |
| C            |                                                      | FCR 3010 |
| [******<br>[ | COMPLEX VECTOR                                       | FOR 3020 |
|              | IF (ABS(HS(IEN,NA)).LE.ABS(HS(NA,IEN))) GO TO 138    | FCR 3040 |
|              | HS(NA, NA)=0/HS(IEN, NA)                             | FOR 3050 |
|              | HS(194,1EN)=-(HS(1EN,1EN)-2)/HS(1EN,19)<br>CD TD 139 | FOR 3050 |
| 138          | CONTINUE                                             | FOR 3080 |
|              | Z3=CMPLX(ZERO,-HS(NA,IEN))/CMPLX(HS(NA,NA)-P,Q)      | FQR 3090 |
|              | HS(NA, IEN)=T3(2)                                    | FQR 3110 |
| 139          | HS(IEN, NA)=ZERO                                     | FOR 3120 |
|              | H5(1EN,1EN)=UNE<br>TENM2=NA-1                        | FUR 3130 |
|              | IF (IENM2.EQ.0) GO TO 145                            | FCR 3150 |
|              | DO 144 II=1, IENM2                                   | FOR 3160 |
|              | 1~(34711<br>U≈HS(1,1)-P                              | FOR 3180 |
|              | RA=ZERO                                              | FOR 3190 |
|              | SA=H3(I, IEN)<br>DD 140                              | FDR 3200 |
|              | RA=RA+HS(I,J)*HS(J,NA)                               | FQR 3220 |
|              | SA=SA+HS(1,J)*HS(J,IEN)                              | FOR 3230 |
| 140          | CONTINUE                                             | FUR 3240 |

IF (NIM(I).GE.ZER0) GO TO 141 22=N R=R0 ธะรก 00070 144 NEI IF (UINCI).NE.IERO) 60 70 142 20=CHPLX(-RA,-SA)/CMPLX(U.O) 141 115(T/MA)=73(1) H3(1,IEH)=73(2) GO TO 144 С SOLVE COMPLEX EQUATIONS []\*\*\*\*\*\* С X=K3(I, T+1) Y=K3(I+1,1) VR=(NRL(I)-P)\*(NRL(I)-P)+NIM(I)\*NIM(I)-S\*3 VI=(NRL(I)-P)\*0 142 01-01-01 U1=U1=U1=U1 17 (UR.EG.ZERBIAND.UI.EG.ZERB) UR=RDELP\*RNDRM\*(ABS(W)+ABS(D)) +DBS(N)+DBS(Y)+ADB(ZZ)) 20=CNPLN(X#R+ZD\*RA+0\*SC),M\*S=ZZ\*SA=0\*RA)/CNPLN(UR,UI) 15(I.MA)\*TB(1) 15(I.MA)\*TB(1) 15(I.MA)\*TB(2) 15(I.MA)\*TB 1 69 70 144 CONTINUE ZC=CHPLK(-R-V\*H3(I+NA),-S-Y\*H3(I+IEN))/CHPLX(ZZ,0) H3(I+1+NA)=T8(1) 143 HS(I+1, IEN)=TS(2) 144 CONTEMUE С END COMPLEX VECTOR C\*\*\*\*\* C 145 CONTINUE C END DACKSUDSTITUTION C###### [24\*\*\*\* VECTORS OF ISOLATED ROOTS С DO 147 7=1.N 17 (1.69.K.AND.I.LE.L) GO TO 147 DO 143 JAIN 201.00003(1.0) 
 IV.2
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 143 CONTINUE 147 CONTINUE IF (L.E0.0) GD 70 153 С C###### MULTIPLY BY TRANSFORMATION MATRIX С DD 150 JU=K.N 日本日本的(しょし) BD 140 1+K+L 22+2200 BD 143 KA=K+M ZT=ZT+ZCT+KA)\*HS(KA+J) CONTINUE 143 2(15,0=22

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| 143<br>150                         | CONTINUE<br>CONTINUE<br>CONTINUE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | FOR               | 2850<br>2850     |
|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|------------------|
| ſ                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | FCR<br>FCR        | 2270             |
| Cassaa                             | * NO CONVERGENCE AFTER 30 ITERATIONS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | FCR               | 2850             |
| Č*****                             | SET ERROR INDICATOR TO THE INDEX                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | FER               | 3290             |
| ្រទននេះន                           | * CF THE CURRENT EIGENVALUE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | FER               | 3910             |
| 0                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | LCS               | 3850             |
| 151                                | ITR=120ALEN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | FCR               | 3230             |
|                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | - rUK             | 2040             |
|                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | - ECR             | 2520             |
| • 5-33                             | Contrastration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | FPR               | 2820             |
|                                    | TE (TELTIND GO TO 155                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | FER               | 3230             |
|                                    | BD 151 IH141                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | E C R             | 3230             |
|                                    | DD 153 V=1-1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 1.C.S             | 4000             |
|                                    | Z(E,C)=ZERO                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | FCR               | <010             |
| .23                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                   | 4020             |
| 1.00                               | la de la companya de<br>La companya de la comp                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | - FCR<br>- FPD    | - 4020<br>- 6060 |
|                                    | ACT FERENCE (FERSENERALS)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | FCR               | 4050             |
| 133                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 103               | 4060             |
| С                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ECS.              | -4070            |
|                                    | E13                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | FCR               | 4020             |
| ~                                  | (IDROUTENE FROMOGI (A)K,L,N,IA,D)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | - FC5             | 10               |
| ىر بىرىم يەرىپى<br>بىر بىر بىر بىر | ·····································                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                   | 20               |
| ່).<br>ເ                           | ризмины ск. – накак систерскими и и кали и и и и и и и и и и и и и и и и и и                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | *215              | 20               |
| Daaraa                             | * THES EVENDED RAN PERFERING THE FOLLOWING FUNCTION:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | *78S              | 50               |
| 2                                  | A TAL DEDITE A REAL MAYOR TO UPPER MESSENDERS FORM THRU                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | *FUS              | <b>C</b> 0       |
| 7                                  | a contrative representations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | *7115             | 70               |
| 0                                  | O DE MANTER                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 1715              | EU<br>60         |
| ୍ରରେଜନ୍ମ ଜନ୍ମ<br>ଅନ                | Re (11.5 tube) kundeliko birediki un nakikini ikiniz <b>s</b> :<br>A serendaki na perenda na perenda na vezetneza <b>na vezetneza</b> . <b>Sida</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | ******<br>******* | 100              |
|                                    | 2 11 11 11 11 11 11 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 1<br>2 11 11 11 11 11 11 11 11 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11 12 11                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | *255              | 110              |
| È                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | *FHS              | 120              |
| 1                                  | A THE STALE CONTRACTOR OF MATRIX A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | *FES              | 130              |
| 2                                  | OPENDED OF TRANSFORMATION FOR SUBSEQUENT USS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 47 HS             | -140             |
| <u>е</u>                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1115              | 150              |
| ្រុងទងដន<br>ក្រ                    | аардаларта состольства, со са сала и калала и калалана кили накини накини накини накини накака накина накака на<br>Парадаларта состольства соста соста са                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | on ne<br>PHB      | 100              |
| C .                                | ANTENATOR ACTIVITY AND                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | FES               | 180              |
|                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | FI:S              | 120              |
|                                    | LA 신규석                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | FES               | 200              |
|                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1115              | - 210            |
|                                    | 72 (1917)/2018 (1917) 199 (1917)<br>29 (1917) 197 (1917)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 115               | 220              |
|                                    | under and each set of the set of | n no<br>muq       | - E30<br>240     |
|                                    | stand sector and the | FES               | 250              |
|                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | FES               | 2G0              |
| 2                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | (TES              | - 270            |
| ្រុងខ្លួងខ                         | * SCALE COLUMN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | FUS               | 280              |
| -2                                 | and the second second                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 115               | 250              |
|                                    | () () () () () () () () () () () () () (                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | בורי<br>בורי      | 200              |
| • 0 •                              | n na sa                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 115               | 220              |
| 19 <b>-</b> 1                      | COLLET CARTER CARTER COLLEG                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>FIIS</b>       | 230              |
|                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1115              | 240              |
| ç                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1113              | - 330            |
| 1.42223                            | ▶                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1115              | - 290            |

| С        | 102        | D0 102 II=M,L<br>I=MP-II<br>D(I)=A(I,M-1)/SCALE<br>H=H+D(I)*D(I)<br>CONTINUE<br>G=-SIGN(SGRT(H),D(M))<br>H=H-D(M)*G<br>D(M)=D(M)-G<br>D0 105 J=M,N<br>F=ZERO | FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF | 270<br>280<br>290<br>400<br>420<br>420<br>420<br>420<br>420<br>420<br>420<br>420<br>42 |
|----------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|----------------------------------------------------------------------------------------|
| С<br>С   | ****       |                                                                                                                                                              | FHS<br>FHS                             | 480<br>490                                                                             |
| С        | 103        | DO 103 II=M,L<br>I=MP-II<br>F=F+D(I)*A(I,J)<br>CONTINUE<br>F=F/H                                                                                             | FHS<br>FHS<br>FHS<br>FHS<br>FHS        | 500<br>510<br>520<br>530<br>540<br>550                                                 |
| _        | 104<br>105 | A(I,J)=A(I,J)-F*D(I)<br>CONTINUE<br>CONTINUE<br>DO 108 I=1,L<br>F=ZERO                                                                                       | FHS<br>FHS<br>FHS<br>FHS<br>FHS<br>FHS | 530<br>570<br>580<br>590<br>600<br>610                                                 |
| C)<br>C) | ***        | ** III 30 J=L•M•-1                                                                                                                                           | FHS                                    | 620                                                                                    |
| C        |            | DO 106 JJ=M,L<br>J=MP-JJ<br>F=F+D(J)*A(I,J)                                                                                                                  | FHS<br>FHS<br>FHS<br>FHS               | 630<br>640<br>650<br>650<br>670                                                        |
|          | 106        | CONTINUE<br>F=F/H<br>DO 107 J=M,L<br>A(I,J)=A(I,J)-F*D(J)                                                                                                    | FHS<br>FHS<br>FHS<br>FHS               | E80<br>650<br>700<br>710                                                               |
|          | 107<br>108 | CONTINUE<br>CONTINUE<br>D(M)=SCALE*D(M)<br>A(M,M-1)=SCALE*G                                                                                                  | FHS<br>FHS<br>FHS                      | 720<br>730<br>740                                                                      |
| ſ        | 109<br>110 | CONTINUE<br>RETURN                                                                                                                                           | FHS<br>FHS                             | 760                                                                                    |
| L        |            | END                                                                                                                                                          | FHS<br>FHS                             | 780<br>790                                                                             |

SUBROUTINE GZOC (N, EV, EVALS, EMAT, CMAT, EMAT, BH, CH, X, Y, NPCRT, PR, MP, MGZC 10 (1S)GZC 20 С CZC 30 \*\*GZC \*GZC 40 С 44 50 THIS SUB-PROGRAM PERFORMS THE FOLLOWING FUNCTIONS: 1. OBTAIN AND STORE COMPLETE INFORMATION ABOUT THE OPEN-CIRCUIT IMPEDANCE MATRIX IN PARTIAL FRACTION \*GZC \*GZC C\*\*\*\*\*\* 60 ē c 70 \* \*GZC 80 4 ĉ EXPANSION (PFE) FORM. \*GZC 20 × 2. CHECK OF JU-AKIS OR REPEATED EIGENUALUES. 3. PRINT ENTRIES OF ZOC, IF REQUESTED. Ĉ \*GZČ 100 Ĉ æ \*GZC 110 ē \*GZC \*GZC \*GZC 120 C\* THIS SUB-PROGRAM WEES THE FOLLOWING SUBROUTINE: \*\*\*\* 120 1. CZOCPR С ¥ 140 2. \*\*\*\* LINEO4 \*\*\*\* LIBRARY DEFENDENT ROUTINE \*GZC \*GZC C C \* 150 160 **0** THIS SUB-PROGRAM#S GLOSSARY OF FORTRAN NAMES: \*GZC \*GZC **C**# \*\*\* 170 ALL VARIABLE NAMES AND ARRAYS AS DEFINED IN SUB-PROGRAM AMAIN C C 180 44 \*620 190 \*\*\* \*GZC 200 Ci С CZC 210 COMPLEX EVALS(1), EV(MS, 1), X(MS, 1), Y(MS, 1), SUM, BH(MS, 1) GZC 530 COMPLEX CH(MP, 1) CZC 530 INTEGER ER, TYPE, PR GZC 240 GZC DIMENSION EMAT(MS,1), CMAT(MP,1), DMAT(MP,1), NPORT(1) 250 GZC GZC COMMON /ENOS/ NCAP, NOUS, NRES, NIND, NDCS, NCPRT 260 C 270 C\*\*\*\*\*OBTAIN THE INVERSE OF THE MODAL MATRIX GZĆ 280 CZC C 290 DO 104 I=1.N GZC 300 DO 102 J=1,N Y(I,J)=CMPLX(0.00,0.00) GZC GZC 310 220 220 102 104 Y(I,I)=CMPLX(1.00,0.00) GZC GZC 340 С GZČ 250 360 GZC GZC 370 C CALL LINEG4 (EU, Y, X, 20, N, N, IERR) IF (IERR.NE.0) GO TO 122 GZC 380 GZC 390 EO 103 I=1.H CZC 400 ED 105 J=1,N
U=REAL(EV(I,J))
U=AI(AG(EV(I,J)) GZC 410 420 czč 420 GZC 440 U1=REAL(X(I,J)) UI=ATMAS(X(I,J)) IF (AES(U),LT.1.00E-15) U=0.0000 IF (AES(U),LT.1.00E-15) U=0.0000 IF (AES(U1),LT.1.00E-15) U=0.000 IF (AES(U1),LT.1.00E-15) U1=0.000 CZC <50 GZC 460 470 GZC GZC GZC 480 490 EU(I,J)=CMPLX(U,V) GZC 500 X(I,J)=CMPLX(U1,V1) GZC 510 103 CONTINUE 520 C 530 C##### FORM THE TINU#EMAT PROBUCT 540 550 C DO 110 I=1.N DO 110 J=1.NCPRT SUM=CMPLX(0.0900.0.0000) GZC 550 570 GZC 520 GZC GZC GZC 590 EO 103 K≈1+N SUM=SUM+X(I,K)\*DMAT(K,J) E00 103

| -        | 110  | BH(I,J)=SUM<br>CONTINUE                                              | GZC<br>CZC   | 610<br>620       |
|----------|------|----------------------------------------------------------------------|--------------|------------------|
| L<br>Ca  |      |                                                                      | 620          | 630              |
| č        |      |                                                                      | 620          | 650              |
| •        |      | DO 114 I=1.NCPRT                                                     | GZC          | 650              |
|          |      | DO 114 J=1,N                                                         | ĞZC          | 670              |
|          |      | SUM=CMPLX(0.00,0.00)                                                 | GZC          | 630              |
|          |      | DO 112 K=1,N                                                         | GZC          | 690              |
|          | 112  | SUM=SUM+CMAT(I,K)*EV(K,J)                                            | GZC          | 700              |
|          |      | CH(I,J)=SUM                                                          | GZC          | 710              |
| r        | 114  |                                                                      |              | 720              |
| č        |      | CHECK FOR REPEATED OR JU-AXIS FIGENUALUES:                           | 620          | 740              |
| č        |      |                                                                      | CZC          | 750              |
|          |      | IWARN1=0                                                             | GZC          | 760              |
|          |      | IWARN2=0                                                             | GZC          | 770              |
|          |      | DO 120 I=1.N                                                         | GZC          | 7'80             |
|          |      | U1=REAL(EVALS(I))                                                    | GZC          | 790              |
|          |      |                                                                      | 626          | 800              |
|          | 116  | J-141<br>TE (J.GT.N) GD TD 118                                       | 620          | 520              |
|          | 110  | U2=REAL(EVALS(J))                                                    | GZC          | 830              |
|          |      | V2=AIMAG(EVALS(J))                                                   | GZC          | £40              |
|          |      | AU=ABS(U2-U1)                                                        | GZC          | 850              |
|          |      | AU=AES(U2-U1)                                                        | GZC          | 630              |
|          |      | IF ((AU.LT.1.000E-08).AND.(AU.LT.1.00E-08)) IWARN1=1                 | GZC          | 870              |
|          |      | L+L=L                                                                | 626          | -230<br>550      |
|          | 118  | TE (ARS(U1),CT.1 ODE-08) CD TD 120                                   | 620          | C00              |
|          | 110  | IWARN2=1                                                             | GZC          | 510              |
|          |      | EUALS(I)=CMPLX(-0.1000,U1)                                           | GZC          | 520              |
|          | 120  | CONTINUE                                                             | GZC          | S30              |
|          |      | IF (IHARN1.EG.1) WRITE (6,124)                                       | GZC          | 540              |
| c        |      | IF (IWARN2.EU.I) WRITE (5,125)                                       | 626          | 500              |
|          |      | WRITE THE INVERSE OF THE NODE ADMITTANCE IN PEE FORM. IF DESIRED     | 620          | 530              |
| č        |      |                                                                      | GZC          | EE0              |
| -        |      | IF (PR.NE.1) RETURN                                                  | CZC          | 590              |
|          |      | CALL GZOCPR (CH, BH, Y, N, NPORT, DMAT, EVALS, MP, MS)               | GZC          | 1000             |
|          |      | RETURN                                                               | GZC          | 1010             |
|          | 122  |                                                                      | GZC          | 1020             |
| r        |      | RETURN                                                               | 620          | 1020             |
| ų        | 124  | FORMAT (1H0.13H** WARNING **./1H .47HREPEATED EIGENVALUES. ANSWER    | SGZC         | 1050             |
|          |      | 1 MAY BE INACCURATE)                                                 | GZC          | 1050             |
|          | 126  | FORMAT (1H0,13H** WARNING **,/1H ,37HJW-AXIS POLE PRESENT HAS BEEN   | NGZD         | 1070             |
|          |      | 1 SHIFTED)                                                           | GZC          | 1030             |
| -        | 128  | FORMAT (1H0,22HSINGULAR MODAL MATRIX )                               | 620          | 1050             |
| C        |      | END                                                                  | 626          | 1100             |
|          |      | SUBROLITINE GZOCPR (CHAT. RHAT. X. NSTU. NPORT. DMAT. FUALS. MP. MS) | 62C<br>67P   | 1110             |
| С        |      |                                                                      | GZP          | żŏ               |
| Č,       |      | ***************************************                              | ▶GZP         | 30               |
| C.       | **** | ** THIS SUB-PROGRAM PERFORMS THE FOLLOWING FUNCTION:                 | ≈GZP         | 40               |
| C        |      | 1. PRINT THE ENTRIES OF THE OPEN-CIRCUIT IMPEDANCE MATRIX            | *C22*        | 50               |
| C        |      | TIN MAKITAL FRAUTION EXPANSION FORM, IF REQUESTED.                   | FUZH<br>NC70 | - <del>Б</del> О |
| С.<br>Г. |      | THIS SUR-PROCRAMES CLOSSARY OF FORTRAN NAMES:                        | ∿υ2Π<br>κΩ7Ρ | 20<br>20         |
| č        |      | ALL UARIABLE NAMES AND ARRAYS AS DEFINED IN SUB-PROGRAM              | RGZP         | 50               |

| 0      |     | *              | ZDC.                                                                                                    | ିପ୍ଟେମ<br>କର୍ଯ୍ୟନ<br>କଳକର୍ମ୍ୟନ | 100<br>110 |
|--------|-----|----------------|---------------------------------------------------------------------------------------------------------|--------------------------------|------------|
| ř      |     |                |                                                                                                         | C7P                            | 130        |
| 2      |     | COMPI          | 1 FY FHAT(M2, 1), FUAT(MS, 1), Y(MS, 1), FUALS(1)                                                       | C7P                            | 140        |
|        |     | DIME           |                                                                                                         | C7P                            | 150        |
|        |     |                | N ZENGZ NCCD NDUG NDC NIN, NDC NCDT                                                                     | 626                            | 100        |
|        |     | 1.12171        | F (6.10c)                                                                                               | 621                            | 170        |
|        |     | 50 1           | 04 (-1.NOPRT                                                                                            | 626                            | 100        |
|        |     |                |                                                                                                         | 621                            | 100        |
|        |     | 10 10          | REFERENCES INCOMENTATION NOCOTATION                                                                     | 62F                            | 200        |
|        |     | 1              | $\square 102 K-1 NCTH$                                                                                  | 626                            | 210        |
|        | 102 | ц.<br>У        | U IUE N-1913IV<br>(1.8)-CHAT(I K)*EUAT(8 4)                                                             | 62F<br>670                     | 220        |
|        | 102 |                | (1)()-CHH((1)()/CH(())))<br>9775 (Ch(1)) (V(1)()) (CH(C)()) (CH(C)())                                   | 62F                            | 220        |
|        |     |                | NITE (B, 110) (A(1,K))(CHES(K))(K=1,HS(0))                                                              | 625                            | 230        |
|        | 101 | NONT:          | TNUE (0)12E) DAMI(1)0)                                                                                  | 627                            | 240        |
|        | 104 | DET            |                                                                                                         | 625                            | 230        |
| ~      |     | REIL           | K11                                                                                                     | 625                            | 220        |
| L      | 100 | 503M           | AT (111 DRUDDEN CEREUIZ ENDERANCE MATRIX)                                                               | 625                            | 200        |
|        | 103 | FORM           | AT (IMI)ESHOPEN LIKUUIT INFEDANCE NATRIAT<br>AT (IM SUBY IN TO INF IN TO ONLY AND ION ZUBERIDUE OTH ION |                                | 280        |
|        | 203 |                | A: (1A)CA1()1A)12)1A))1A)12)2A)//A )//AA/(AKEDIDUE)2(A)10)<br>(UT)                                      | 1616626                        | 200        |
|        | 110 |                | 1017)<br>At (111 - Ev F12 F AUX 1 F12 F 4V F12 F AUX 1 F12 F)                                           |                                | 210        |
|        | 110 | F CK/II        | AI (IN , 37,512,3,207),112,3,47,512,3,207,0,512,3)                                                      | 626                            | 220        |
| r      | 115 | r ukra         | A) (INU;SALUNSIAN1~;E12.5)                                                                              | 628                            | 220        |
| L      |     | END            |                                                                                                         | 625                            | 220        |
|        |     | רוש.<br>שמוש   | OUTINE LOODDA (NERTO NOTE DUAT OUAT FLUE NOTDED DAT 20 201                                              |                                | 340        |
|        |     | CUDRI<br>107 N | UTINE RURDRI (NEREUNDIO) BART, UNRT, EV, A, NEEREU, DHT, 23, 231.<br>27 NZTI MIN DHARE NE MEN           | LOSHOT                         | 20         |
| ~      | -   | INC+IN         | 21,1211,117,200,02,00,002                                                                               |                                | 20         |
| 5      |     |                | *******                                                                                                 |                                | 20         |
| r<br>r |     |                |                                                                                                         |                                | 50         |
|        |     |                | HTC CHREGODODAM DEDERBYC THE COLLOHING CHNETTON.                                                        | *001                           | 50         |
| 5      |     | सन   <br>अर    | 1 COMPUTE THE EXPERIMENT TO POLICIANTS FORCE ON AT FACH                                                 | ×H01                           | 20         |
| č      |     |                | I. CONFOLT AND NECTIVE INDUITED CONFULTION HILL CHEMIC                                                  | ALCO1                          | 0<br>0     |
| ř      |     |                | FUSITIVE AND ALGATIVE INFOR FREEDENCT VALUE.                                                            | ~HO1                           | 90         |
| 5      |     | а.<br>Ті       | HTE ENDLEDARDAMME I DECADU DE EDETRAN NAMES.                                                            | #UD1                           | 100        |
| ř      |     |                | NIDEO • NUMPEO OF PORTAINE APPLIE FRENUENCIES                                                           | *P01                           | 110        |
| ř      |     | -<br>-         | NOTH NUMBER OF FOSTE HOSTARDES (CISCIDIT COMPLEY                                                        |                                | 120        |
| č      |     |                | HIT IN THE DOT FIGELOGIES TRANSFER FUNCTION HA                                                          |                                | 120        |
| ř      |     | 3              | AT HILL ERFORMENCY HOLDS                                                                                | #H01                           | 140        |
| ř      |     | н.             | ALL DIVER HOTORIE NAMES AND ADDAYS AS DEFINED IN                                                        | * 401                          | 150        |
| ř      |     | *              | SUB-SDOCDAM ANATN                                                                                       | *H01                           | 160        |
| ř      |     | **             |                                                                                                         | *H01                           | 170        |
| č.     |     | *****          | *****                                                                                                   | HERRHO1                        | 180        |
| ř      |     |                |                                                                                                         | HOI                            | 190        |
| U      |     | וכממס          | IFX SUM.S.FU(1).CHOT(MR.1).BYOT(MS.1).H(MR.1).TH                                                        | HOI                            | 200        |
|        |     | ודאית          | NSTAN DAT(M2.1). NEART(1)                                                                               | EQ1                            | 210        |
|        |     | COXN1          | NN ZENSZ WY(10).6MP(10).TH(10).LUNIT                                                                    | нат                            | 220        |
|        |     | DIME           | NSTON EHASE(5)                                                                                          | HOI                            | 230        |
|        |     | COMM           | DN Z016Z NEONT(32).JCONT(10)                                                                            | HD1                            | 240        |
|        |     | COMM           | ON ZENOSZ NCGP. NDUS. NZES. NIND. NDCS. NOUT                                                            | нот                            | 250        |
| C      |     | 00             |                                                                                                         | HO1                            | 260        |
| Č,     |     | ** FO          | RM POSITIVE AND NEGATIVE FREQUENCY ARRAY FOR ANALYSIS                                                   | H01                            | 270        |
| č      |     |                |                                                                                                         | H01                            | 280        |
| -      |     | DD 11          | 05 I=1,NFRED                                                                                            | HO1                            | 290        |
|        |     | Ē              | =NEREQ+I                                                                                                | HO1                            | 300        |
|        |     | P              | HASE(I)=3.141552654*PHASE(I)/180.0000                                                                   | H01                            | 310        |
|        |     | τi             | H(I)=CMPLX(0.0000,PHASE(I))                                                                             | HOI                            | 350        |
|        |     | Ť              | H(K)=CNPLX(0.0000,-FHASE(I))                                                                            | HOI                            | 330        |
|        |     | e<br>la        | MP(K)=6MP(I)                                                                                            | HO1                            | 340        |
|        | 103 | ui (K          | )=-W1(I)                                                                                                | KOI                            | 350        |

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230
270
230
230
350
C
                                                                                                                                                                                                          HG1
C***** OBTAIN THE FIRST-CREER TRANSFER FUNCTION AT EACH FREQUENCY POINT HOL
                                                                                                                                                                                                          EO1
C
                                                                                                                                                                                                          HO1
                 DO 140 L=1,NFRED
                          IF (LUNIT.E0.2H HZ) WI=2.00000*3.141522554*W1(L)
                                                                                                                                                                                                          H01
                                                                                                                                                                                                                        400
                          S=EMPLX(0.00, NI)
                                                                                                                                                                                                          EO1
                                                                                                                                                                                                                        610
                          DO 135 I=1,NOUT
                                                                                                                                                                                                         420
                                  SUM=CHPLX(0.00,0.00)
                                                                                                                                                                                                                        420
                                  DO 110 K=1,NSTU
                                                                                                                                                                                                                        4.40
                                                                                                                                                                                                                       480
480
470
                                  SUN=SUM+CHAT(I,K)*DHAT(K,1)/(S-EV(K))
     110
                                  DHAT=EMT(1,1)
                                 E0 TD (115,120,125), NZT
H(I,L)=(SUM+CMFLX(CEAT,0.0000))/CMFLX(25,0.000)
                                                                                                                                                                                                                       420
     115
                                  CO TO 120
                                                                                                                                                                                                                        rðj
      120
                                  H(I,L)=(SUM+CMPLX(DHAT,0.0000))*25*5
                                                                                                                                                                                                                            Ξó
                                  CO TO 130
                                                                                                                                                                                                                        520
      123
                                  H(I,L)=(SUM+CMPLX(BHAT,0.0000))/25/S
      130
                                 H(I,NFRE0+L)=CONUS(H(I,L))
                                                                                                                                                                                                          Ł
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                         CONTINUE
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     140 CONTINUE
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C***** COMPUTE RESPONSE DUE TO SECOND-GENERATOR, IF PRESENT
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С
                                                                                                                                                                                                          NC1 / NC1
                 IF (MIX.NE.1) GO TO 175
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                                                                                                                                                                                                                            10
                 INP2=NCONT(LOSRC)
                                                                                                                                                                                                          NEFRED=2*NFRED
                                                                                                                                                                                                                        C
                                                                                                                                                                                                                              . )
                                                                                                                                                                                                                       LED
                 DO 170 I=1,NOUT
                          SUM=CMPLX(0.0000,0.0000)
                                                                                                                                                                                                                        C
                                                                                                                                                                                                                              ٦
                          EO 145 K=1, NSTU
                                                                                                                                                                                                                        030
     145
                          SUM=SUM+CHAT(I,K)*BHAT(K, INP2)/(S-EV(K))
                                                                                                                                                                                                          E
                                                                                                                                                                                                                        030
                                                                                                                                                                                                          HDI
HDI
HTI
                         DMAT=DMT(I,INP2)
GD TD (150,155,160), MZT1
H(I,NFRED)=(SUM+CMPLX(DMAT,0.000))/CMPLX(ZS1,0.0000)
                                                                                                                                                                                                                        C70
                                                                                                                                                                                                                        £
                                                                                                                                                                                                                              ۰ŋ
                                                                                                                                                                                                                       200
2003
                                                                                                                                                                                                          HOI
HOI
HOI
     150
                         GO TO 165
      155
                         H(I,NFRED)=(SUM+CMPLM(EMAT,0.000))*ZS1*S
                                                                                                                                                                                                                            10
                         GO TO 165
H(I,NFREO)=(SUM+CMPLX(DHAT,0.000))/251/5
                                                                                                                                                                                                         H01
H01
H01
                                                                                                                                                                                                                        12)
72)
      160
                         H(I,NEFRED)=CONUS(H(I,NFRED))
                                                                                                                                                                                                          HD:
                                                                                                                                                                                                                         140
      163
      170 CONTINUE
                                                                                                                                                                                                                        150
                                                                                                                                                                                                             700
770
      175 RETURN
С
                                                                                                                                                                                                                        7007
101
                END
                SUBROUTINE HORDRE (NFRED, NSTU, NNELEM, EV, BHAT, CHAT, H. H2, N2FRED, W2, NHC
                                                                                                                                                                                                                ÷,
                                                                                                                                                                                                        20
20
               11CS, TEMP, DMT, N2FRPT, FCU, NPOUT, MP, MS)
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                         THIS SUB-FROGRAM PERFORMS THE FOLLOWING FUNCTION:

1. COMPUTE THE SECOND-ORDER TRANSFER FUNCTION VALUES AT

COMDINATION OF A PAIR OF POSITIVE AND NEDATIVE INPUT
                                                                                                                                                                                                                          C0
C******
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#201
#202
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                                               FREQUENCY VALUES.
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                        THIS SUB-PROGRAMAS BLOSBARY OF FORTHON MANES:4012H2(I,J) : I-TW PORT SECOND-ORDER MRANSFER FUNCTION4172WALUE AT FREQUENCY MELL4022W2(I) : I-TW FREQUENCY VALUE AFFEARING IN THE SECOND-4029ORFER GREGTRUM4022N2FRPT : TOTAL NUMBER OF FREQUENCY PDINTS AFFEARING4022IN THE SECOND-CREER SFECTRUM4022
C##
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FCU(I) : I-TH FREQUENCY COMBINATION CODE SRC2(L) : SECOND-CREER CURRENT SOURCE DUE TO THE L-TH NIMLINEAR ELEMENT GUL OTHER VARIABLE MANES AND ARRAYS AS DEFINED IN \*H03 \*H03 0000000 -3 180 ä 150 \*803 ä 200 \*H02 ö 210 220 230 SUD-FROGRAM AMAIN \*H02 4 æ \*HC2 C× 240 C 230 INTEGER FOU(1) COMPLEX SUM,S,EU(1),EMAT(MS,1),EMAT(MP,1),H(MP,1),W2(MP,1) COMPLEX SEC2(23),VENP(MP,1),CP,S3,S3,TH DEMENSION W2(1), EWT(MP,1) COMMON 2002/ H1(10),GEP(10),9) COMMON 2002/ H1(10),GEP(10),TH(10),LUNIT COMMON 2002/ H1(10),GEP(10),TH(10),LUNIT COMMON 2002/ H1CPNT(22),JCENT(10) COMMON 2002/ NCAP,M2U3,MRES,HINS,MEDS,MCS DATE M 2001/2 230 270 280 EATA NL/2HNL/ K=0 NEFRED=2\*NFRED С C\*\*\*\*\*INITIALIEE HOR HOR HOR HOR HOR Ĉ ED 105 E=1,NICS 105 ERC2(I)=CMPLX(0.00,0.00) 400 410 C 420 HD2 C\*\*\*\*\* COMPUTE SECOND-CREER TRANSFER FUNCTIONS AT EACH FREDUENCY COMBI 430 С 440 DO 193 II=1,MOFRED DO 195 JU=II,MOFRED DUM=M1(II)+M1(JU) 459 450 470 H02 H02 K=K+1 400 1:3(K)=200 450 HENGEDON FEU(G)=100II+JJ IF (GUNIGLEGLEH HZ) EUM=2.0000000003.141592554\*(W1(II)+W1(JJ)) S=CHPLK(0.00,EUM) 500 H02 H02 H02 H02 510 5<u>2</u>0 530 £ C\*\*\*\*\* FORM SECOND-CREER DURRENT SOURCE VECTOR 540 550 550 570 DD 100 L=1, NNELEM L3=3\*(L-1)\*NPCUT+2 IDDN1=NOCNT(L3) IDDN3=NOCNT(L3+1) INDEX=JODN(L3+1) 530 590 **G**00 CO YO (110,115,120,125), INDEX 610 650 C\*\*\*\*\* NONLINEAR CAPACITIVE SOURCE 630 C:40 C ERCE(L)=H(ICON1, II)+H(ICON2, JU)+AI(L, 2)+S 110 650 CO TO 130 ES0 H02 670 С 102 CANNAN NONLINEGR INDUCTIVE SOURCE E30 FC2222222 Ĉ 630 IF (EUM.50.0.00) 60 TO 100 STO2(L)=H(ICCN1.II)\*H(ICCN2.JU)\*AI(L.2)/S CO TO 130 200 115 710 720 730 749 С C\*\*\*\*\* NONLINEAR DEFENSENT SOURCE HC2 HC2 750 C SP=(KIOCN1, FID#MCICON1, JUD#AI(L, 3) SD=NCLSDN2, SID#MCICEN2, JUD#AI(L, 4) 760 120 ECP 770

|          | 1    | S<br>⁄       | S=(H(ICON1,II)*H(ICON2,JJ)+H(ICON2,II)*H(ICON1,JJ))*AI(L,<br>2.00                              | 5) HO2<br>HD3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 780<br>720     |
|----------|------|--------------|------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
|          | -    | S            | RC2(L)=+(SP+SQ+SS)                                                                             | HO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 800            |
| _        |      | G            | O TO 130                                                                                       | H03                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 810            |
| C        |      |              |                                                                                                | HOS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 653            |
| - U#     | **** | NUNLIN       | EAR RESISTIVE SOURCE                                                                           | ROS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 830            |
| L        | 125  | c            | 902(1)-H(ICON1.II)=H(ICON2.11)=AI(1.2)                                                         | - FiU2<br>200                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 520            |
|          | 130  | CUNT         | TNUF                                                                                           | F00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | - 600<br>ESU   |
| С        | 100  | Conn         |                                                                                                | 1.22                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 570            |
| - Ē*     |      | FORM Z       | OC( S1+S2 )                                                                                    | H23                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Ē30            |
| C        |      |              |                                                                                                | F:22                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 850            |
|          |      | DO 1         | 40 J=1,NCS                                                                                     | H03                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | - <b>S</b> 00  |
|          |      | 00 1         | 40 M=1,NCS                                                                                     | HC2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | - 510          |
|          |      | 5            | UN=UN/LX(0.00,0.00)<br>D 125 L -1 NETU                                                         | - 번신고<br>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - 520<br>- 520 |
|          | 125  | L<br>C       | UM=SUM+CHAT(.1.1)+RHAT(L.M)/(S+FU(L.))                                                         | FC2<br>200                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 500<br>520     |
|          | 133  | n<br>D       | HAT=DMT(.1.M)                                                                                  | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 530            |
|          |      | Ť            | ENP(J,M)=SUM+CMPLX(DHAT,0.0000)                                                                | HO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 530            |
|          | 140  | CONT         | INUE                                                                                           | НŪЗ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | £70            |
| С        |      |              |                                                                                                | HOB                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 530            |
| -C*      | **** | OBTAIN       | SECOND-ORDER TRANSFER FUNCTIONS                                                                | HC3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | CE3            |
| C        |      | <b>DO 1</b>  |                                                                                                | FLC2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1000           |
|          |      | 101          | 20 J=1+NLS<br>UM=CMBLY(0 00.0 00)                                                              | 802                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1020           |
|          |      | n            | 0 145 M=1.NNFLFM                                                                               | HUD                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1020           |
|          |      | -            | M3=3*(M-1)+NPOUT+1                                                                             | 1:02                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1040           |
|          |      |              | ICON=NCONT(M3)                                                                                 | H02                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1050           |
|          | 145  | S            | UM=SUM+TEMP(J.ICON)*SRC2(M)                                                                    | EC3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1030           |
|          |      | H            | 2(J,K)=SUM                                                                                     | HG2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1070           |
|          |      | I            | F ((NTYPE(J).EO.NL).AND.(DUM.EO.00.09)) H2(J,K)=0.00                                           | HO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1020           |
| c        | 150  | LUNI         | INUE                                                                                           | 1122<br>1122                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 1100           |
| L        | 155  | CONTINU      | C                                                                                              | LUDO                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1110           |
|          | 100  | N2FRPT=      | u<br>K                                                                                         | HC2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1120           |
|          |      | RETURN       |                                                                                                | H25                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1120           |
| С        |      |              |                                                                                                | HC3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1140           |
|          |      | END          |                                                                                                | H23                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1150           |
|          |      | SUBROUT      | INE HORDR3 (NFR, NSTU, NAELEM, EU, BHAT, CHAT, H1, H2, N2F, W3, H3,                            | NIHD3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 10             |
| ~        | 1    | CS+ IEMP     | • UMT• KX•FCV• NPUUT• NP• NS )                                                                 | - ಗಾರ<br>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 20             |
| С.<br>Г. |      | ******       | *****                                                                                          | +~800<br>₩≉803                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 40             |
| Ē.       |      | *            |                                                                                                | <ul> <li>100</li> <li>100</li></ul> | 50             |
| Č.       | **** | * THIS       | SUB-PROGRAM PERFORMS THE FOLLOWING FUNCTION:                                                   | *803                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | ĒÓ             |
| С        |      | *            | 1. COMPUTE THE THIRD-ORDER TRANSFER FUNCTION VALUES AT                                         | <b>*</b> ≾63                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 70             |
| С        |      | *            | EACH POSITIVE COMBINATION OF THREE POSITIVE AND                                                | *HC3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 63             |
| Ē        |      | #            | NEGATIVE INPUT FREQUENCIES TAKEN AT A TIME.                                                    | *103                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 50             |
|          |      | #<br>* TUTC  | CUD-DBOCDAMAC CLOCCARY DE ECOTRAN NAMEC.                                                       | ಗಳಲ್ಲಿ<br>ಕಳಲ್                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 200            |
| r"       |      | #<br>≍ 1⊔⊺⊃  | BUDTERUGRADED GLUDDERT UF FUR BRAZD.<br>H3(I.)) : I-TH PORT THIRD-GROER TRANSFER FUNCTION HALL |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 120            |
| č        |      | *            | AT FREQUENCY US(J)                                                                             | *EDS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 120            |
| ć        |      | *            | W3(J) : J-TH POSITIVE FREQUENCY VALUE AFPEARING IN                                             | *H23                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 140            |
| Ċ        |      | *            | THE THRD-ORDER SPECTRUM                                                                        | *X03                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 150            |
| C        |      | *            | FCU(J) : NB(J) FREQUENCY CONSINATION CODE                                                      | *803                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 160            |
| č        |      | *            | SRC3(L) : IHIRD-ORDER CURRENT SOURCE DUE TO L-TH                                               | *823                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 170            |
| Ľ        |      | <del>.</del> | NUNLINERK ELENENI<br>All Atmer Hariarie Nomie and Crrays as refined in                         | - ಕೋಷಿಟೆ<br>ಕಾರ್ಯ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 100            |
| č        |      | -<br>*       | SUR-PROGRAM AMAIN                                                                              | <ul> <li>€□22</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 200            |
| č        |      | *            |                                                                                                | *H23                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 210            |
|          |      |              | 建苯基苯基基 化化化化化 化化化化化化化化化化化化化化化化化化化化化化化化化化化                                                       | **U02                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                |

С HD3 230 INTEGER FDU(1) \_\_\_\_\_\_\_ COMPLEX SUM, S.EU(1), EXAT(MS, 1), CHAT(MP, 1), H1(MP, 1), H2(MP, 1), SRC3(2H03 COMPLEX SUM, S.EU(1), EXAT(MS, 1), CHAT(MP, 1), H1(MP, 1), H2(MP, 1), SRC3(2H03 COMPLEX SUM, S.EU(1), EXAT(MS, 1), CHAT(MP, 1), H1(MP, 1), H2(MP, 1), SRC3(2H03 COMPLEX SUM, S.EU(1), EXAT(MS, 1), CHAT(MP, 1), H1(MP, 1), H2(MP, 1), SRC3(2H03 COMPLEX SUM, S.EU(1), EXAT(MS, 1), CHAT(MP, 1), H1(MP, 1), H2(MP, 1), SRC3(2H03 COMPLEX SUM, S.EU(1), EXAT(MS, 1), CHAT(MP, 1), H1(MP, 1), H2(MP, 1), SRC3(2H03 COMPLEX SUM, S.EU(1), EXAT(MS, 1), CHAT(MP, 1), H1(MP, 1), H2(MP, 1), SRC3(2H03 COMPLEX SUM, S.EU(1), EXAT(MS, 1), CHAT(MP, 1), H1(MP, 1), H2(MP, 1), SRC3(2H03 COMPLEX SUM, S.EU(1), EXAT(MS, 1), CHAT(MP, 1), H1(MP, 1), H2(MP, 1), SRC3(2H03 COMPLEX SUM, S.EU(1), EXAT(MS, 1), CHAT(MP, 1), H1(MP, 1), H2(MP, 1), SRC3(2H03 COMPLEX SUM, S.EU(1), EXAT(MS, 1), CHAT(MP, 1), H1(MP, 1), H2(MP, 1), SRC3(2H03 COMPLEX SUM, S.EU(1), SRC3(2H03), SRC3( 240 250 15), TEMP(MP, 1), H3(MP, 1), G31, G32, G23, G34, G231, G232, G233, G234, TH 260 DIMENSION W3(1), BAT(MP,1) DEMENSION W3(1), BAT(MP,1) DEMADN 2001/ NTYPE(10),AI(10,9) DEMADN 2003/ W1(10),ANP(10),TH(10),LUNIT DEMADN 2016/ NEONT(32),JEDNT(10) H03 270 H03 230 H03 290 H03 300 COMMON /ENOS/ NCAP, NOVS, NRES, NUND, NDCS, NCS H03 310 DATA NL/2HNL/ r 03 320 330 KK=0 HD3 340 C E03 C\*\*\*\*\* INITIALIZE EBB 350 350 £ E03 E0 105 I=1.NICS 105 SRC3(I)=CMPLX(0.00,0.00) E03 370 803 380 С HD3 390 C\*\*\*\*\* COMPUTE THIRD-ORDER TRANSFER FUNCTION AT EACH FREQUENCY COMB K03 400 C H03 410 DJ 153 I=1,NFR ноз 420 155 J=1, MEF 153 K=J, MEF H03 430 HD3 440 EUM=111(I)+111(J)+111(K) ноз 450 IF (DUM.LT.0.00) GD TO 155 H03 460 KK=KK+1 HD3 470 NBCKKO=DUM ноз 420 FEU(KK)=100\*1\*10\*J+K IF (LUNIT.ED.2H HZ) BUM=2.0000\*3.141592654\*BUM S=CNPLK(0.00,BUM) H03 490 500 803 803 510 IDUM=(I-1)\*M2F-I\*(I-1)/2 520 803 II=JEUM+U I2=JEUM+K 530 E03 ED3 5⊿∩ J1=(J-1)=N2F-J\*(J-1)/2+K HO3 550 03 560 C C\*\*\*\*\* FORM NONLINEAR CURRENT SOURCE VECTOR ноз 570 H03 530 BO 130 L=1, NNELEM 803 590 L3=3\*(L-1)+NPCUT+2 IC1=NCONT(L3) IC2=NCONT(L3+1) H03 600 HO3 610 H03 E50 G31=H1(IC1,I)\*H1(IC1,J)\*H1(IC1,K) G231=H1(IC1,I)\*H2(IC1,J)+H1(IC1,J)\*H2(IC1,I2)+H1(IC1,K)+H2(HO3 630 640 IC1,I1) ED3 650 1 G231=2.0000\*G231/3.00000 H03 660 INDEX=UCONT(L) G0 TO (110,115,120,125), INDEX 803 670 H03 630 H03 690 C\*\*\*\*\* NUNLINEAR CAPACITIVE SOURCE 700 BD3 H03 C 710 110 SRC3(L)=(G31\*AI(L,3)+G231\*AI(L,2))\*S HD3 720 GO TO 130 H03 730 E03 740 C C\*\*\*\*\* NONLINEAR INDUCTIVE SOURCE H03 750 E03 760 С IF (DUM.E0.0.00) GO TO 130 H03 770 115 5703(L)=(G31\*AI(L,3)\*G231\*AI(L,2))/S 803 780 GO TO 130 HC3 790 HD3 800 C 810 C\*\*\*\*\* NONLINEAR DEPENDENT SOURCE H03 HD3 \$20 C

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|        | 120    | G232=H1(IC2,I)*H2(IC2,J1)+H1(IC2,J)*H2(IC2,I2)+H1(IC2,K)*H2                                                                    | 2(H03            | 830        |
|--------|--------|--------------------------------------------------------------------------------------------------------------------------------|------------------|------------|
|        | 1      | 162,11)<br>6233=H1(101,1)*H2(102,11)+H1(101,0)*H2(102,12)+H1(101,K)*H2                                                         | ECH<br>PERM      | 840<br>850 |
|        | 1      | IC2, I1)                                                                                                                       | H03              | 850        |
|        |        | G234=H1(IC2,I)*H2(IC1,J1)+H1(IC2,J)*H2(IC1,I2)+H1(IC2,K)*H2                                                                    | 2(H03            | 870        |
|        | 1      | 161/11)<br>CS2=H1(TC2,T)%H1(TC2,1)%H1(TC2,K)*A1(L.Z)                                                                           | H03              | 880        |
|        |        | G33=(H1(IC1,I)*H1(IC1,J)*H1(IC2,K)+H1(IC1,J)*H1(IC1,K)*H1(I                                                                    | CHO3             | 500        |
|        | 1      | 2,I)+H1(IC1,K)*H1(IC1,I)*H1(IC2,J))*AI(L,8)/3.0000                                                                             | ROB              | S10        |
|        | ,      | G34=(H1(IC1,I)*H1(IC2,J)*H1(IC2,K)+H1(IC1,J)*H1(IC2,K)*H1(I<br>D I)*H1(IC1,K)*H1(IC2,J)*H1(IC2,J)*A7(L,D)/2,000                | CH03             | 550        |
|        | 7      | G231=G231*AI(L,3)                                                                                                              | - H03<br>- H03   | 230<br>240 |
|        |        | G232=2.0000*G232*AI(L,4)/3.00000                                                                                               | HOS              | £30        |
|        |        | SRC3(L)=G231+G232+(G233+G234)*AI(L,5)/3.00+G31*AI(L,5)+G32+                                                                    | -6H03            | 230        |
|        | Ţ      | 53+634<br>60 TO 130                                                                                                            | 803              | 530        |
| С      |        |                                                                                                                                | H03              | ĒĐO        |
| C*     | ****   | NONLINEAR RESISTIVE SOURCE                                                                                                     | HO3              | 1000       |
| U      | 125    | SBC3(1)=C31*A1(1.3)+C231*A1(1.2)                                                                                               | F.03             | 1(20       |
|        | 130    | CONTINUE                                                                                                                       | FOS              | 1030       |
| C      |        |                                                                                                                                | НDЗ              | 1040       |
| C.4    | ****   | FURM ZUC ( 51+52+53 )                                                                                                          | H03              | 1050       |
| C,     |        | DO 140 JJ=1,NCS                                                                                                                | H03              | 1070       |
|        |        | DO 140 M=1,NCS                                                                                                                 | HD3              | 1080       |
|        |        | SUM=CMPLX(0.00,0.00)                                                                                                           | - HO3            | 1090       |
|        | 135    | SUM=SUM+CHAT(JJ,L)*BHAT(L,M)/(S-EV(L))                                                                                         | H03              | 1110       |
|        |        | DHAT=DMT(JJ,M)                                                                                                                 | HD3              | 1120       |
|        | 140    | TEMP(JJ,M)≃SUM+CMPLX(DHAT,0.000)                                                                                               | H03              | 1130       |
|        | 140    | DO 150 JJ=1,NCS                                                                                                                | H03              | 1150       |
|        |        | SUM=CMPLX(0.00,0.00)                                                                                                           | H53              | 1160       |
|        |        | DO 145 M=1,NNELEM                                                                                                              | HD3              | 1170       |
|        |        |                                                                                                                                | HSB              | 1190       |
|        | 145    | SUM=SUM+TEMP(JJ, ICON)*SRC3(M)                                                                                                 | H03              | 1200       |
|        |        | H3(JJ,KK)=SUM<br>TE ((NTYPE(LL) ED BL) AND (DUM ED 0 00)) H3(LLKK)=0.00                                                        | H03              | 1210       |
|        | 150    | CONTINUE                                                                                                                       | K03              | 1230       |
| С      |        |                                                                                                                                | H03              | 1240       |
|        | 155    |                                                                                                                                | H03              | 1250       |
| С      |        |                                                                                                                                | 803              | 1270       |
| -      | ł      | END                                                                                                                            | H03              | 1230       |
| c      | ļ      | SUBROUTINE IWRIST (NFREQ,HI,NPORT,IAP,NOUT,MP)                                                                                 | 1111             | 10         |
| Č*     | ****   | *****                                                                                                                          | 1911.<br>1111.** | 30         |
| Ĉ      | •      |                                                                                                                                | *IW1             | 40         |
| C#     | +##### | IHIS SUB-PRUGRAM PERFORMS THE FOLLOWING FUNCTION:<br>1 PRINT THE EIGST-OPDED TRANSFER FUNCTION AND OUTPUT                      | **_W1<br>**_1(1  | 50<br>60   |
| č      |        | UDLTAGE VALUES AT EACH POSITIVE INPUT FREQUENCY VALUE                                                                          | #IW1             | 70         |
| 2      | ÷      | AT THE REQUESTED PORTS.                                                                                                        | * I.11           | 03         |
|        | :<br>  | NAMES:                                                                                                                         | *1111<br>#2111   | 50         |
| č      |        | <ul> <li>HIG 300 FROM THE GEOGRAPHIC OF FORTHALLS.</li> <li>HI(I,J) : UPON ENTRANCE: I-TH PORT FIRST-ORDER TRANSFER</li> </ul> | 2#2W1            | 110        |
| Ĉ      |        | FUNCTION VALUE AT W1(J); UPON EXIT: I-TH FOR                                                                                   | *1U1             | 120        |
| C<br>C | •      | CUTPUT VOLTAGE VALUE AT FREQUENCY W1(J)                                                                                        | * 111            | 130        |
| L.     | -      | • THE • EKINING OFFICE VERIABLE                                                                                                | - 1 MI           | 240        |

ALL OTHER VARIABLES NAMES AND ARRAYS AS DEFINED IN C #TW1 :50 č SUB-PROGRAM AMAIN. \*IN1 160 č \*7.01 170 3 C+ \*\*IW1 180 Ċ TU1 190 DIMENSION NPORT(1) COMPLEX H1(KP,1),TH COMMON /003/ W1(10), 6MP(10),TH(10),LUNIT IU1 200 TWI 210 THI 220 COMMON /ENGS/ NCAP, NDVS, NRES, NIND, NDCS, NCS IW1 230 C IWI 240 C\*\*\*\*\* CHECK IF RESPONSE IS TO BE PRINTED AT ALL EXTRACTED PORTS IWI 250 Ĉ IW1 260 IF (IAP.E0.1) GO TO 105 I!!: 270 L=2 IWI 280 K=NOUT IW1 290 GO TO 110 105 L=1 300 71/1 IK1 310 220 K=NCS IWI 230 C IHI C\*\*\*\*\* PRINT THE FIRST-ORDER TRANSFER FUNCTION AND RESPONSE AT EACH 2141 240 350 350 370 C\*\*\*\*\* CUTPUT PORT AND FRECUENCY TLIL Ē TUH 110 D9 130 I=1,NFRE0 WRITE (6,155) I,W1(I),LUNIT WRITE (6,145) WRITE (6,145) IW1 380 7.01 390 IW1 141 <00 DO 125 J=L,K EW1 410 IOUT=NPORT(J) IW1 420 AMAGN=CABS(H1(IOUT,I)) IW1 430 U=-REAL(H1(IOUT,I)) IWI 440 U=~AIMAG(H1(IGUT,I)) H1(IGUT,I)=AMP(I)\*H1(IGUT,I)\*CEXP(TH(I)) 450 IW1 IW1 450 YMAG=CABS(H1(ICUT,I)) IWI 470 YU=-REAL(H1(IDUT,I)) 430 IWI YU=-AIMAG(H1(IOUT,I)) IWI 490 IF (AMASH.ED.0.0000) GD TO 115 ADB=20.000\*ALCG10(AMAGN) PHASE=ATAN2(YU,YU)\*180.000/3.141592654 IW1 500 510 TW1 520 TW1 GO TO 120 530 IW1 115 AD3=-1.005+30 540 TU1 PHASE=0.00000 550 TUI WRITE (6,150) IDUT, U, U, AMAGN, ADB, YU, YV, YMAG, PHASE 560 120 IW1 CONTINUE 570 125 1111 130 CONTINUE 530 TUI 590 RETURN IWI С TUI 600 135 FORMAT (1H0, 12HFIRST ORDER:, 15X, 11HFREDUENCY( , I1, 5H )= , E10.3, 2XIW1 610 1,63) IU1 650 140 FORMAT (1H0, 34X, 17HTRANSFER FUNCTION, 40X, 14HOUTPUT VOLTAGE) 630 IW1 143 FORMAT (//1X, SH PORT , 8X, 4MREAL, 8X, SHIMAGINARY, 5X, SHMAGNITUDE, 6IW1 640 1X, SH20LOG MAG, 9X, 4HREAL, 8X, 9HIMAGINARY, 5X, 9HMAGNITUDE, 6X, SHPHASE, / IWI 650 2,5%,2HND,114%,3HDEG,7,1H,3%,4(1H.),6%,57(1H.),3%,53(1H.)) 150 FORMAT (1H,4%,12,4%,7(3%,212.5),3%,F7.2) IU1 660 IW1 670 С IW1 680 END IW1 690 SUBROUTINE IWREND (NFRED, NEFRPT, H2, NPDRT, IEFC, W2, IAP, NDUT, MP) IW5 10 IN5 20 C 30 Ĉ# \*\* \*IN5 40 C \*IW2 C\*\*\*\*\*\* THIS SUB-PROGRAM PERFORMS THE FOLLOWING FUNCTION: \* I WS 50

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1. PRINT THE SECOND-ORDER TRANSFER FUNCTION AND OUTPUT VOLTAGE VALUES AT EACH OF THE MON-NEGATIVE FREQUENCY VALUES AT THE REQUESTED PORTS. С \* 11:2 80 70 . \*122 ē \* č -Ξ9 ຮັງ 

 THIS SUB-PROGRAM#S GLODSARY OF FORTRAN NAMES:
 \*102

 NBERPT
 TOWAL NUMBER OF FORTRAN NAMES:
 \*102

 NEFRPT
 TOWAL NUMBER OF FORTRAN NAMES:
 \*102

 SEDEND-GREER RESPONDE
 \*102

 H2(1,J)
 UPDN ENTRANCE:
 1-TH PORT SEDEND-CREER TRANSFE:

 FUNCTED:
 UPDN ENTRANCE:
 1-TH PORT SEDEND-CREER TRANSFE:

 BUDGTED:
 UPDN ENTRANCE:
 1-TH PORT SEDEND-CREER TRANSFE:

 FUNCTED:
 UPDN USLYE AT NECUD:
 1000 EXT:

 SUB-DRUCU:
 SUB-PROGRAM AMAIN.
 \*102

 SUB-PROGRAM AMAIN.
 \*102

 C\* C \*\*\*\* 100 - 34 110 3 120 0000 ₩ \* 끃 Ĉ ē 궔 С С \*0.2 SUB-PROGRAM AMAIN. 才 \$ **╋净ท售薪售需要推销销售价值销售**就在这些价格就能让你就没有这些资格还是这些保证的这些存在这些公式的,你就是你能让你能够给你的你能够给你们。 200 C C 210 DIMENSION NPORT(1), ISFC(1), H2(1) 200 200 240 COMPLEX H2(MP,1),TH COMMON 20032 NI(10),AMP(10),TH(10),ULNIT COMMON 22NDS2 NCAP,NEUS,NEES,H1H2,M2DS,HD3 55 175 230 230 270 C C\*\*\*\*\*CHECK IF RESPONSE IS TO BE FRINTED AT ALL EXTRACTED PORTS Ĉ IF (IAP.E0.1) GO TO 103 L=2 K=NOUT GO TO 110 105 L=1 112 1.2 K=NCS C C\*\*\*\*\*PRINT SECOND-ORDER TRANSFER FUNCTION AND RESPONSE AT EACH OUTPUT 1.2 C\*\*\*\*\*PORT AND POSITIVE FREQUENCY C 110 DO 130 I=1, N2FRPT IF (W2(1).LT.0.000) GD TO 130 С C\*\*\*\*\* DECIPHER FREQUENCY COMBINATION С ICOME=I2FC(I) II=ICOM3/10 JJ=ICOMB-10+II LL=JJ 400IF (LL.GT.NFRED) LL=NFRED-LL 400 -100 500 110 1 10 1 10 11/2 AMAGN=CABS(H2(IOUT,I)) U=REAL(H2(IOUT,I)) 123 5.40 120 130 170 U=AIMAG(H2(IOUT,I)) 11/2 H2(IOUT, I)=AMP(II)\*AMP(JJ)\*H2(IOUT, I)\*CEXP(TH(II))\*CEXP(TH(J)) 1 ງ)) 00 20 20 14.12 21(2 IF (II.E0.JU) M2(IOUT,I)=M2(IOUT,I)/CM2LX(2.000,0.000) £ IF (11.E0.33) P2(100,1)=M2(100 YMAS=CAB3(P2(1007,1)) YU=RIAL(H2(1007,1)) YU=AIMAS(H2(1007,1)) IF (AMAGN.E0.0.0000) ED TO 115 APD=20.0000\*AL0510(AMACH) Ĺ ;  $\Gamma_1$ i î î ) ໄວກໍ 13 12 - 4 FHASE=ATAM2(YU,YU,#10).000/3.14152E334 CE0

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212

GO TO 120 115 ALD=-1.000E+S0 FWASE=0.0000 120 URITE (G.1S0) ICUT, U.V. AMAGN, AB3, YU, YV, YMAG, PHASE 125 CONTINUE 120 CONTINUE RETURN C30 C70 IN3 630 еãõ 112 700 · · · · · · · 710 720 С 7:30 740 750 760 770 780 750 200 E 810 END EUDROUTINE INRERD (NERED, NEERFT, HO, NEORT, ISFO, W3, IAP, NOUT, MP)  $5 \geq 0$ 10 C 20  $\mathbb{E}0$ 40 THIS SUD-FROGRAM PERFORMS THE FOLLOWING FUNCTION: 1. FRINT THE WHERD-FORER TRANSFER FUNCTION AND BUTPUT VOLTAGE VALUES AT EACH OF THE NON-NEGATIVE FREQUENCY VALUES AT THE RECLESTED CUTPUT FORTS. Cossees \*173 ΞO 60 Ĉ \*113 æ Ĉ \*1..3 70 ~ с С ä \*:::3 80 ¢. \*IK3 Ēθ \*1N3 \*1N3 \*1N3 NGARPT : TOWNY MUNCER OF FORTRAM NAMES: NGARPT : TOWNY MUNCER OF NON-NEGATIVE FREQUENCY CONFONEING IN TWE THIRD-CROER SFEDTRUM HG(I,J) : UPON ENTRAMOE: I-TH PORT THIRD-CROER TRANSFIR\*1N3 FUNCTION UNLOS IN THE THIRD-CROER TRANSFIR\*1N3 FUNCTION UNLOS AT MOS(J); UPON EXIT: I-TH PORT\*1N3 THORE-CROER CUMPUT VOLTAGE AT FREQUENCY NG(J)\*1N3 ISFO(J) : (13(J) FRECHENCY CONSCINCTION CODE ALL GIMER VARIABLE MANES AND ARRAYS AS DEFINED IN \$US SUD-FREGERM AMAIN \*1N3 100 220 120 130 40 -15 0000000 150 4 160 35 -35 170 \*123 \*123 ų, 120 65 200 510 PENERSION NPERT(1), ISFC(1), W3(1) COMPLEX M3(NP,1), TH CENMENT 20027 M1(10), GMP(10), TH(10), LUNIT COMMENT 20028 M1(10), GMP(10), TH(10), LUNIT 220 230 230 240 143 142 143 230 COMMON VENDS/ NDAP, HEVS, NRES, MEND, NECS, NCS 11/3 230 C\*\*\*\*\* CHECK IF RESPONSE IS TO DE FRINTED FOR ALL EXTRACTED PORTS C 270 123 1113 1113 230 IF (IAP.E0.1) GD TD 103 220 K=3 L=NDUT IN3 200 IN3 310 11:3 320 330 GG TO 110 350 340 30 7113 103 K=1 1113 1113 LENCS 350 C\*\*\*\*\* PRINT THIRD-CREER TRANSFER FUNCTION AND RESPONSE AT EACH OUTPUT C\*\*\*\*\* PRINT AND POSITIVE FREQUENCY POINT 330 370 тиз IN3 230 380 143 143 C 110 ED 120 I=1,HEFRPT С IK3 400 C\*\*\*\*\* ESCIPHER FREQUENCY CONDINATION 1113 410 11!3 420 430 ICOND=ISFC(I) 11/3

213

|    | II=ICOMB/100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | IN3          | 440            |
|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|----------------|
|    | JJ=(ICDMB-100#II)/10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | IМЗ          | 450            |
|    | KK=ICOMB-100*II-10*JJ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | I::3         | 430            |
|    | LI=1L                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | IW3          | 470            |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 123          | 430            |
|    | IF (JI.GT.NFRED) JI=NFRED-JI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 183          | 490            |
|    | IF (K1.GT.NFRED) K1=NFRED-K1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | IK3          | 500            |
|    | WRITE (6,135) II, J1, K1, W3(I), LUNIT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 11/3         | 510            |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 163          | - 520          |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 183          | 530            |
|    | UU I 25 J = K + L                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 143          | 240            |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | TMR          | 200            |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1.40         | 550            |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 183          | 2.0            |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 160          | 250            |
|    | $\mathbf{D}(0 + CAPEX(1, 0, 0, 0, 0))$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 140          | 520            |
|    | IF ((II, EG, GG, U, CG, EG, K, Y) = II (-EnFEX(E, COG, O, CO))                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 163          | 610            |
|    | = 11 - ((11, -1), -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, -0, -1) - (0, | 100          | E20            |
|    | H3(1007)1)-1-0000000 (11)-0000000 (10)-00000000000000000000000000000000000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 1703         | 620            |
|    | YNGELORS (HSCIDIT, T))                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | IU3          | - 630<br>- 630 |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 11/3         | 650            |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | TW3          | 650            |
|    | IE (AMAGN.ED.0.0000) GO TO 115                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | TW3          | 670            |
|    | ADB=20,000*6LOG10(6MAGN)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 11:3         | E30            |
|    | PHASE=ATAN2(YU,YU)+180.00/3.141592654                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | IK3          | 690            |
|    | GO TO 120                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1K3          | 700            |
|    | 115 ADB=-1.000E+30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 143          | 710            |
|    | PHASE=0.000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | IКЗ          | 720            |
|    | 120 WRITE (6,150) IOUT, U, V, AMAGN, ADB, YU, YV, YMAG, PHASE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | IN3          | 730            |
|    | 125 CONTINUE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | INC          | 740            |
|    | 130 CONTINUE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1W3          | 750            |
|    | RETURN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | IW3          | 760            |
| С  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 143          | 770            |
|    | 135 FORMAT (1H0,12HTHIRD ORDER:,15%,11HFREQUENCY(,11,1H,,12,1H,,12,5H                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | HIM3         | 780            |
|    | 1 = .E10.3.2X.A3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | IK3          | 750            |
|    | 140 FORMAT (1H0, 34%, 17HTRANSFER FUNCTION, 40%, 1490UTPUT VOLTAGE)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | IW3          | - <u>5</u> 00  |
|    | 145 FORMAT (2/1X,9H PORT ,8X,4KREAL,8X,9H1MAGINARY,6X,9HMAGNITODE,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 5143         | 810            |
|    | IX, SH20LOU NAG, 9X, 4HREAL, 8X, SHIMAGINARY, 5X, SHAAGNI (DDE, 5X, SHPHASE)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 103          | 520            |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 183          | 230            |
| ~  | 130 FURPHI (10 +4X,12,4X,7(3X,E12,5),5X,F7,2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1112         | 540            |
| 6  | END                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 103          | 500            |
|    | CIRPOLITINE INFORM (V1.V2.V3.NEPED.NOEPET.NEEPET.FR.V.MOUT.U2.U3.I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 165          | 10             |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 195          | ົ້ວດ້          |
| c  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | JSP          | 20             |
| čı | ·*************************************                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | JSP          | 40             |
| č  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | SP.          | 50             |
| Ē٠ | ****** THIS SUB-PROGRAM PERFORMS THE FOLLOWING FUNCTIONS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | +JSP         | 60             |
| Ċ  | <ul> <li>1. PERFORM AN VHISTOGRADY ANALYSIS OF ALL THE OUTPUT</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | *JSP         | 70             |
| С  | <ul> <li>FREQUENCY COMPONENTS AND CONSINE THE REPEATED ONES.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | *JSP         | 80             |
| С  | * 2. PRINT AND PLOT THE COMPLETE OUTPUT SPECTRUM.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | *JSP         | S0             |
| C  | *                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | *CSP         | 100            |
| C• | *##### THIS SUB-PROGRAM USES THE FOLLOWING SUDROUTINES: 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | "JSP         | 110            |
| C  | + 1. JPLTS <sup>2</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | *JSP         | 120            |
| С  | +                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | *JSP         | 130            |
| C+ | ****** THIS SUB-PROGRAMAS CLOSSARY OF FORTRAN NAMES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | *JSP         | 140            |
| č  | <ul> <li>Y1(I, J) : I-TH FORT FIRST-DRDER RESPONSE AT W1(J)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | *125         | 150            |
| ç  | <ul> <li>Y2(1,J) : I-TH PDTT SECOND-OTDER RESPONSE AT W2(J)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 1157<br>1157 | 160            |
| C  | ★ Y3(I,J) : I-TH POPT THIPD+OREER RESPONSE AT W3(J)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | °JSP         | -170           |

: TOTAL NUMBER OF INPUT FREQUENCIES : TOTAL NUMBER OF POSITIVE AND NEGATIVE FREQUENCIES IN THE SECOND-ORDER RESPONSE : TOTAL NUMBER OF NON-NEGATIVE FREQUENCIES IN THE THIRD-ORDER RESPONSE : VALUES OF DISTINCT FREQUENCIES IN THE OUTPUT \*JSP NEREO С 180 ÷ NEFRPT #JSP :90 #ಪಿSP 200 #JSP 4 NSFRAT 210 \*JSP 220 æ FR #JSP 230 SPECTRUM #JSP 240 : CUTPUT PORT VOLTAGE AT FREDUENCY FR(I) : OUTPUT PORT INDEX Y(I) +JSP 250 NOUT \*JSP 260 YLG(I) : LOG OF THE OUTPUT VOLTAGE AT FREQUENCY FR(I) #JSP 뀪 270 \* JSP 280 Č# C -USP 290 JSP 200 COMPLEX Y1(MP,1),Y2(MP,1),Y3(MP,1),Y(1),TH DIMENSION FR(1), W2(1), W3(1), IPT(1), YLG(1), IFRUNT(2) COMMON 20032 W1(10),AMP(10),TH(10),LUNIT COMMON 20162 MCONT(22),JCONT(10) JSP 310JSP 320 JSP 330 JSP 340 DATA IFRUNT(1), IFRUNT(2)/7HRAD/SEC, 7H HERTZ / JSP 350 (דעסא=דעסע JSP 350 ICON=2 JSP 370 JSP 380 С C\*\*\*\*\* PACK THE VARIOUS CROER RESPONSES FOR THE REQUESTED OUTPUT JSP 390 C\*\*\*\*\* PORT INTO AN ARRAY FOR "HISTOGRAM" ANALYSIS JSP 400 JSP 410 C DO 105 I=1.NFRED FR(I)=W1(I) JSP 420 JSP JSP 430 105 Y(I)=Y1(JOUT.I) 44N JSP KOUNT=NFRED 450 С С С JSP 4G0 JSP SECOND-ORDER RESPONSE 470 JSP 480 JSP DO 110 I=1.N2FRPT 490 JSP IF (W2(I).LT.0.00) GD TO 110 500 KOUNT=KOUNT+1 JSP 510 Y(KOUNT)=Y2(JOUT, I) JSP 520 FR(KCUNT)=W2(I) JSP 530 110 CONTINUE JSP 540 С JSP 550 C C THIRD-ORDER RESPONSE JSP 560 JSP 570 DO 115 I=1.NEFRPT JSP 580 KOUNT=KOUNT+1 JSP 590 JSP Y(KOUNT)=Y3(JOUT, I) 600 JSP FR(KOUNT)=W3(I) 610 115 CONTINUE ĴŜP 620 JSP 630 С JSP C\*\*\*\*\* INITIALIZE 640 JSP С E50 JSP ED 120 I=1.KOUNT E60 120 IPT(I)=I JSP 670 JSP 680 С C\*\*\*\*\* PERFORM ~HISTOGRAM~ ANALYSIS JSP 690 JSP 700 С NFPT1=KOUNT-1 JSP 710 JSP DO 135 I=1.NFPT1 720 IPTUAL=IPT(I) JSP 730 IF (IPTUAL.LT.I) GO TO 135 JSP 740 FFRED=FR(1) JSP 750 JSP 760 I1=1+1 DO 130 J=11.KOUNT JSP 770

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IF (FR(J).EQ.PFREQ) GO TO 125 JSP 780 GO TO 130 JSP 720 Y(I)=Y(I)+Y(J)**J**EP **E**00 125 IPT(J)=IPTUAL JSP 810 130 CONTINUE วีริจ 820 135 CONTINUE 122 633 С 725 £40 C\*\*\*\*\* PRINT COMPLETE OUTPUT SPECTRUM 830 C **E**S0 IF (LUNIT.E0.3HRAD) ICON=1 870 WRITE (6,155) JOUT WRITE (6,160) IFRUNT(ICON) JSP 880 JSP 850 DO 150 I=1,KOUNT JSP 200 IPTVAL=IPT(I) JSP 510 IF (IPTUAL.LT.I) GO TO 150 **US**P 220 AMAGN=CABS(Y(I)) 222 230 រត<u>ិតិតិត</u>ិត ភូមិល U=REGL(Y(I))£40 £30 U=AIMAG(Y(I)) IF (AMAGN.EQ.0.000) GD TO 140 **S**30 YLG(I)=ALOG10(AMAGN) 270 152 230 PHASE=ATAN2(U,U)\*180.000/3.141592654 GO TO 145 JSP 230 JEP 1000 JEP 1010 140 PHASE=0.000 USP 1010 USP 1020 YLG(I)=-1.000E+30 145 WRITE (6,165) FR(I), U, U, AMAGN, PHASE JEP 1030 150 CONTINUE JEP 1040 C USP 1030 C\*\*\*\*\* PLOT THE DUTPUT SPECTRUM 1030 С JEP 1070 WRITE (6,170) CALL JPLTSP (FR, YLG, KOUNT, 23, 23HLOG OF OUTPUT MAGNITUDE) WRITE (6, 175) IFRUNT(ICON) JSP 1030 JSP 1090 JSP 1100 RETURN JSP 1110 С 155 FORMAT (1H1, //, 1X, 47HSINUSDIDAL STEADY-STATE OUTPUT RESPONSE AT POUSP 1120 JEP 1130 1RT, 2X, I2, /, 1H , 47(1H.)) 160 FORMAT (///7X, SHFREQUENCY, 11X, 4KREAL, 12X, SHIMAGINARY, 8X, SHMAGNITUDEJSP 1140 1,12X,5HPHASE, /8X,A7,67X,2HDEG, /1H,6X,82(1H.)) 165 FORMAT (1H,5X,E12.2,4X,E12.3,7X,E12.3,5X,E12.3,7X,E12.3) 170 FORMAT (1H1,45X,31HRESPONSE MAGNITUDE US FREQUENCY/) JSP 1150 JSP 1160 JSP 1170 175 FORMAT (1H0,55%, 11HFREQUENCY (, A7, 1H)) JSP 1120 JSP С 1120 JSP 1200 END SUBROUTINE JPLTSP (XX, YY, NDATA, NB, LABEL2) JPT 10 С JP7 50 C\* 30 \*JPT C \* 40THIS SUB-PROGRAM PERFORMS THE FOLLOWING FUNCTION: \*J27 C ------50 1. PLOT THE COMPLETE OUTPUT SPECTRUM. \*JPT ε 60 \*JP7 C 70 THIS SUB-PROGRAM USES THE FOLLOWING SUBROUTINES: \*027 ε0 C 1. JSEP Ĉ . \*JP7 20 2. JLCOMP, JPUT (FUNCTION SUB-PROGRAMS) \*JPT C 100 - 11 \* 127 С 110 

 \*JP1

 THIS SUB-FROGRAM≠S QLOSSARY OF FORTRAN NAMES:
 \*JP1

 XX
 : X COORDINATE OF DATA (FREQUENCY)
 \*JP1

 YY
 : Y COORDINATE OF DATA (FREQUENCY)
 \*JP1

 NB
 : NUMBER OF CHARACTERS IN Y AXIS LABEL
 \*JP1

 LABEL2
 : Y AXIS TITLE IN MOLLERITH FORMAT
 \*JP1

 NDATA
 : NUMBER OF DATA POINTS
 \*JP1

 C+ \*\*\* 150 C .... 130 C ٠ 140 C - 24 150 Ħ 160 C -170

| C      |     | *                                                                                            | #JPT         | 130 |
|--------|-----|----------------------------------------------------------------------------------------------|--------------|-----|
| - C*   | *** | ╅┶╪╪╬╬╔╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬╬                                                     | 146 <b>*</b> | 190 |
| C      |     | REAL JPUT                                                                                    | JPT          | 210 |
|        |     | DIMENSION SYMBOL(4), AMASK(10), XSCALE(12), YSCALE(51), PLOT(51,1                            | OJPT         | 220 |
|        |     |                                                                                              | JPT          | 530 |
|        |     | DIMENSION XX(1), YY(1)                                                                       | 140          | 240 |
|        |     | DININGLUM LEBILE(5), LD(50)<br>DATA (SYM201(1),I=1.4)/10800000000000000000000000000000000000 | 1.IPT        | 250 |
|        |     | LONXXXXXXXXXX/, (AMASX(I), I=1, 10)/77000000000000000000, 77000000000                        | OJPT         | 270 |
|        | i   | 2009000B, 7700000000000003, 7700000000003, 7700000000B, 770000000                            | CJPT         | 580 |
|        |     | 3B,77000000B,770000B,77003,77B/,BLANK/553535353535555555558/,DASH/                           | 1JPT         | 290 |
| r      | 4   | 107/,UPLINE/1071111111111/,PLUS/107+++++++++/                                                | 127          | 200 |
| č      |     | GENERATE GRAPH LABELS                                                                        | JPT          | 320 |
| č      |     |                                                                                              | JPT          | 330 |
|        |     | N2=N3                                                                                        | JPT          | 340 |
| ~      |     | CALL JSEP (6,60,N2,LABEL2,LB)                                                                | 175          | 350 |
| с<br>С |     | ZERA CROPH CREAT TO ON PLANKS                                                                | 197          | 350 |
| č      |     | ZERB BRAITH ARRITH TO HEL BEARING                                                            | JPT          | 380 |
| -      |     | DD 105 I=1,51                                                                                | JPT          | 390 |
|        |     | DJ 105 J=1,10                                                                                | JPT          | 400 |
| c      | 105 | PLU((1, J))=BLANK                                                                            | 171          | 410 |
| ř      |     | FIND DATA MAXIMUM AND MINIMUMS                                                               | JPT          | 430 |
| č      |     |                                                                                              | JPT          | 440 |
|        |     | XMAX=XX(1)                                                                                   | JPT          | 450 |
|        |     | XMIN=XMAX                                                                                    | 191          | 460 |
|        |     | YMAN-YYUI)<br>YMAN-YYUI)                                                                     | .127         | 490 |
|        |     | IF (NBATA.LE.O) GD TD 115                                                                    | JPT          | 490 |
|        |     | DD 110 J=1, NDATA                                                                            | JPT          | 500 |
|        |     | XMAX=AMAX1(XMAX,XX(J))                                                                       | JPT          | 510 |
|        |     | XM2Y=AM1M1(XM2Y,YY(D))                                                                       | JPT          | 520 |
|        | 110 | YMIN=AMIN1(YMIN, YY(J))                                                                      | JPT          | 540 |
|        | 115 | CONTINUE                                                                                     | JPT          | 550 |
| č      |     |                                                                                              | JPT          | 560 |
| ç      |     | DETERMINE X AND Y INCREMENTS                                                                 | JPT          | 570 |
| L      |     | XSC=100./(XMAX-XMIN)                                                                         | JPT          | 590 |
|        |     | YSC=50.0/(YMAX-YMIN)                                                                         | JPT          | E00 |
| C      |     |                                                                                              | JPT          | 610 |
| C      |     | CUNSTRUCT MURIZUNTAL VERERENCE LINES                                                         | JP1<br>IPT   | 620 |
| ι.     |     | NO 123 J=1,51,10                                                                             | JPT          | 640 |
|        |     | IF (I.LT.2) GO TO 125                                                                        | JPT          | £50 |
|        |     | DO 120 J=1,10                                                                                | JPT          | 650 |
|        | 120 | PLUT(I,J)~DASH                                                                               | ואנ          | 670 |
| r      | 153 |                                                                                              | JPT          | 690 |
| č      |     | CONSTRUCT VERTICAL REFERENCE LINE                                                            | JPT          | 700 |
| Ċ      |     |                                                                                              | JPT          | 710 |
|        |     | U703=10                                                                                      | JPT          | 720 |
|        |     |                                                                                              | JPT          | 740 |
|        |     | SYNEUPLINE                                                                                   | JPT          | 750 |
|        |     | TEST=(PLOT(I,JWCRD).AND.AMASK(JPOS))                                                         | JPT          | 760 |
|        |     | TDASH=(DASH.AND.AMASK(JPOS))                                                                 | JPT          | 770 |

IF (JLCOMP(TEST, TDASH).E0.0) SYM=PLUS JPT 780 130 PLOT(I, JMORD)=JPUT(AMASK, I, JMORD, JPOS, SYM, 51, PLOT) JPT 790 000 JP7 200 JPT DETERMINE X, Y LOCATION OF DATA POINTS ON GRAPH 810 JPT 820 NEF=NBATA JPT 830 D0 143 J=1,NDF JYKK=((YY(J)-YMIN)\*YSC+1.5) JPT 840 JPT 850 JPT JX=((XX(J)-XMIN)\*XSC+0.5) 860 UNORD=(UN/10)+1 JPT 870 JPDS=MOD(JX, 10)+1 JPT **E**30 EO 143 JY=1- JYKK JPŤ 890 TEST=(PLOT(JY, JUERD). AND. AMASK(JPOS)) JPT 200 TUP=(UPLINE.AND.AMAEK(UPOS)) TELANK=(ELANK.AND.AMAEK(UPOS)) JPT 910 JPT 220 TELENART (DELARCHAD HAMASK (DPOS)) TELES (DASH.GAD.AMASK (DPOS)) TPLUS=(PLUS.AND.GMASK(JPOS)) IF (JLCCMP(TELANKATEST).E0.0) GD TO 135 IF (JLCCMP(TELANKATEST).E0.0) GD TO 135 IF (JLCCMP(TPLUS,TEST).E0.0) GD TO 135 IF (JLCCMP(TUP.TEST).HE.0) GD TO 140 127 530 JPT £40 JPT \$30 JPT 230 JPT 970 JPT 580 JPT 000 \$30 JPT 1000 INSERT SYMEOL FOR DATA POINT JPT 1010 SVM=SYMBOL(1) 60 70 143 JPT 1020 135 JPT 1030 С JPT 1040 IF MULTIPLE DATA POINTS IN SAME PLOT LOCATION USE = SIGN \*\*\*\*NOTE\*\*\*> = SIGN IS INHIBITED FOR BAR GRAPH FORM OF OUTPUT Ĉ J77 1050 JPT 1050 С ē JPT 1070 140 SYM=SYMDDL(1) 143 PLOT(JY,JWDRD)=JPUT(AMASK,JY,JWDRD,JPDS,SYM,51,PLOT) JPT 1030 JPT 1090 JPT 1100 С JPT 1110 GENERATE X AND Y SCALES С UPT C 1120 JPT 1130 JPT 1140 JPT 1150 JANE=12-1 XLON=XMIN-1.0/XEC JPT 1160 JPT 1170 NINC=100.0/CHMAX-HLCHD JPT 1180 XUL1=(XMAX-FLDAT(10\*I-10)/XINC) JPT 1190 ADLI=CANNASTELLAIC16%1-10)Z EMAGEADS(XUL1) IF (EMAG.LE.0.10) XUL1=0.0 153 XSEAL2(JANE)=XUL1 PRINT\_120 JPT 1200 JPT 1210 JPT 1550 JPT 1230 DO 175 I=1.51 JPT 1240 JC=52-1 JPT 1250 17=11 JPT 1250 17=17-1 JPT 1270 160 IF (IT.E0.1) CO TO 155 IF (PLOT(UC,IT).E0.PLANK) GO TO 150 IF (N2.E0.0) GO TO 170 JPT 1280 JPT 1250 JPT 1300 165 JPT 1310 FRINT 185, LB(I), VSCALE(JC), (PLOT(JC,J), J=1, IT) JPT CO TO 175 FRINT 190, YSCALE(UC),(PLOT(UC,U),U=1,IT) 1320 JPT 170 1330 175 CONTINUE FRINT 180 FRINT 185 JPT 1340 JPT 1350 JPT 1350 PRINT 200, (XSCALE(I), I=1, 11, 2), (XSCALE(I), I=2, 10, 2) JPT 1370

218

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| ~      |      | RETURN                                                                                  | 1 4           | 1280   |
|--------|------|-----------------------------------------------------------------------------------------|---------------|--------|
| L      | 100  |                                                                                         | 171<br>197    | 1000   |
|        | 185  | 5 FRRMAT (18.61,18.59 2.18.14+.10610.65)                                                | 170<br>701    | 1400   |
|        | 190  | ) FORMAT (2X,F10.3.1X,1H+,10A10.AS)                                                     | .127          | 1420   |
|        | 153  | 5 FORMAT (4X, 11(9X, 1HU))                                                              | 175           | 1430   |
|        | 200  | FORMAT (4X,E10.3,3X,5(10X,E10.3)/7X,5(10X,E10.3))                                       | JPT           | 1440   |
| С      |      |                                                                                         | JPT           | 1450   |
|        |      | END                                                                                     | JP77          | 1460   |
|        |      | REAL FUNCTION JPUT(AMASK, J, JWORD, JPOS, SYM, NPDM, PLOT)                              | J.P           | 10     |
| С      |      |                                                                                         | JS            | 50     |
| č      |      | JPUT ARRANGES DATA POINTS FOR PLOTTING                                                  | 12            | 30     |
| С      |      | RIMENCI CN AMACK (10) DI CT (NORM 10)                                                   | 22            | 40     |
|        |      | DIMENSION FINESK(10), PLOTOPEN, 10)                                                     | 27            | 50     |
|        |      | REAL JEUT<br>IPUT-(PLAT( 1, 11021) AND NOT AMAGY( 1993)) NG (AMAGY( 1993) AND           | SAMU 12       | 20     |
|        |      | RETIRN                                                                                  |               | 53     |
| 2      |      |                                                                                         | ູ້ເວ          | ້ອ້    |
| -      |      | END                                                                                     | -<br>L'P      | 100    |
|        |      | FUNCTION JLCOMP(I,K)                                                                    | JLP           | 10     |
| С      |      |                                                                                         | -1_P          | 20     |
| č      |      | JLCOMP ARRANGES DATA POINTS FOR PLOTTING                                                | LLP           | 30     |
| С      |      |                                                                                         | 9 <u>_</u> 1_ | 40     |
|        |      | IF (I.GE.0.FIND.K.C.O) GD TD 105                                                        |               | 50     |
|        |      | 15 (1-0) $16$ 10 10 $10$ 113                                                            | 1 B           | 20     |
|        | 105  |                                                                                         | 10            | 50     |
|        | 103  | RETURN                                                                                  | ." P          | <br>ສາ |
|        | 110  | JLCDMP=0                                                                                | JLP           | 100    |
|        |      | RETURN                                                                                  | <u> </u>      | 110    |
|        | 115  | 5 JLCOMP=-1                                                                             | J'LP          | 150    |
|        |      | RETURN                                                                                  | J'_P          | 130    |
| С      |      |                                                                                         | LLP           | 140    |
|        |      |                                                                                         | <u>115</u>    | 150    |
| ~      |      | SUBRUUTINE JSEP (IDI, IDE, M, LAB, LA)                                                  |               | 10     |
|        |      | A ISED SEPARATES THE ALPHARETS IN THE VANTE LAREL FOR HERTICAL                          |               | 20     |
| C      | **** | ** DISPLAY                                                                              | 920           | 49     |
| č      |      |                                                                                         | 252           | 50     |
| -      |      | DIMENSION LAB(ID1), LA(ID2)                                                             | <u>l</u> ép   | 60     |
|        |      | DATA LANK/10H                                                                           | 552           | 710    |
|        |      | IF (M.LE.O) GO TO 120                                                                   | <b>J</b> SP   | εo     |
|        |      | DO 105 I=1.ID2                                                                          | JSP           | 50     |
|        | 105  | 5 LA(I)=LANK                                                                            | JSP           | 100    |
|        |      | LIM=(M-1)/IU+1<br>DD 115 I1-1 LIM                                                       | 121           | 110    |
|        |      | N=11+T1-T1+1                                                                            | ູ່ມີ          | 120    |
|        |      |                                                                                         | .152          | 140    |
|        |      | K=LABEL                                                                                 | JSP           | 150    |
|        |      | DO 115 I2=1.10                                                                          | JSP           | 160    |
|        |      | SI-N=LL                                                                                 | JSP           | 170    |
|        |      | IF (JJ.GT.M) GO TO 110                                                                  | -SP           | 180    |
| ~      |      | K=MUU(K+64)                                                                             | JSP           | 150    |
|        |      |                                                                                         | 120 4444      | 210    |
| r<br>r |      | איין עטון זפון זבח איין אטראיד אין אטראיד אוויאנע אייייער אייייער אייייער אייייער איייי |               | 220    |
|        |      | K=ISHFTLA(K,54)                                                                         | JSP           | 200    |
|        |      | LA(JJ)=K                                                                                | JSP           | E-10   |
|        | 110  | LABEL=ISHFTRA(LABEL,6)                                                                  | 755           | 230    |
|        | 115  | 5 K=LARFI                                                                               | .192          | - 230  |

Trans.

| c    | 120     | RE              | TURN           |                                                                                    | JSP                | 270        |
|------|---------|-----------------|----------------|------------------------------------------------------------------------------------|--------------------|------------|
|      |         | 22)<br>201      | כ<br>דעסגכ     | INE KFRINC (INTYP, NFRED)                                                          | JSP<br>KFI         | 290        |
| 0    |         | <b>H</b> 46.06. | *****          | ******                                                                             | KFI                | 20         |
| С×   | ****    | ল দেশ<br>ক      |                | ***************************************                                            | *******<br>******* | 30<br>40   |
| č*   | ***     | <b>K</b>        | THIS           | SUB-FRODRAM PERFORMS THE FOLLOWING FUNCTION:                                       | *KFI               | 50         |
| C    |         | Q.              |                | 1. COMPUTE THE FREQUENCY INCREMENTS FOR FREQUENCY SWEEP                            | *KFI               | 60         |
| Ĉ    |         | с;              |                | CAPABILITY.                                                                        | *KFI               | 70         |
| С    |         | -25             |                |                                                                                    | *KFI               | <b>8</b> 0 |
| C₩   | ***     | ¢≯              | THIS           | SUB-FROGRAM#5 GLOEBARY DF FORTRAN NAMES:                                           | *KFI               | 90         |
| C    |         | 4               |                | INTYP : TYPE OF FREQUENCY INCREMENTS (LIN OR LOG)                                  | *KFI               | 100        |
| E    |         | 4               |                | NFRED : NUMBER OF INPUT FREQUENCIES (LE. 5)                                        | *KFI               | 110        |
| 5    |         | - 22<br>        |                | ELE DIRER CRAINEL NOVED RND RKRAID AS DELINED IN                                   | *****              | 120        |
| 5    |         | ы.<br>ж         |                | ECUTTIKUGKANG HANTIN.                                                              | 季代に主               | 140        |
|      |         |                 | ****           | Markar da jan ja ja sa ka                      | やいじよう              | 150        |
| č,   |         |                 |                |                                                                                    | KET.               | 150        |
| 9    |         | CC              | EN EX          | PKSEE                                                                              | KET                | 170        |
|      |         | CO              | NNON -         | /033/ FR3(10),6MP(10),PMASE(10),LUNIT                                              | KFI                | 180        |
|      |         | CO              | NON            | 2004/ NSTPS(5), 7RINC(5), WFR(5)                                                   | KFI                | 190        |
| С    |         |                 |                |                                                                                    | KF I               | 200        |
| C×   | 영 주 주 수 | * C;            | RECK           | IF LINEAR OR LOG INCREMENT IS DESIRED                                              | KFI                | 210        |
| С    |         |                 |                |                                                                                    | KFI                | 220        |
| _    |         | 15              | (1)            | YP.EO.SHUIND GO TO 110                                                             | KFI                | 530        |
| С.,  |         |                 |                |                                                                                    | KFI                | 240        |
| . U* | ****    | * []            | Ju FR          | FUTINEL TURKENTIN 2                                                                | KEL                | 250        |
| ما   |         | ъn              | 107            |                                                                                    | トトリ                | 280        |
|      |         | 10              | 000            | しかした (でき) 「「「」」 「「」」 「」                                                            | NE 1               | 270        |
|      | 105     | 20              | 3163.<br>TNCKT | -2007(00170(1))**(1 000/(STPS-1 000))                                              | 1 1 1              | 290        |
|      | 200     | E =             | 11211          | >=<(i) (<2 >) () () () () () () () () () () () () ()                               | KET                | 300        |
| С    |         | •               | - Civit        |                                                                                    | KFI                | 310        |
| ē*   | ***     | ¥ [             | INEAR          | FREQUENCY INCREMENTS                                                               | KFI                | 320        |
| С    |         |                 |                |                                                                                    | KEI                | 330        |
|      | 110     | ΣO              | 115            | I=1,NFRED                                                                          | ι F Τ              | 340        |
|      |         |                 | STPS           | =FLCAT(NSTF3(I)-1)                                                                 | KFI                | 350        |
|      | 115     | ER.             | 112(1          | )=(HER(I)-FRB(I))/STPS                                                             | KEI                | 360        |
| ~    |         |                 | I URN          |                                                                                    | KF1                | 370        |
| L    |         | EN'             | ~              |                                                                                    | Ki*↓<br>2/57       | 380        |
|      |         | 011             | 0<br>10047     | INT KERHIS (T.NTRER. TELAR)                                                        | VET.               | 330        |
| r    |         | <b>.</b>        |                |                                                                                    | KEU                | 20         |
| Č*   | ***     | ***             | *****          | 숬体숺숺갼궳궎샩갼갼갧갆汑곗냬긷댯믔곗쓌씘 <b>꿁걔줮솒곗쑫뢒</b> 뢒 <b>뢒</b> 뵦닅닅욯챓욯닅닅닅뿉뿉닅닅닅닅                    | *KFU               | 30         |
| ē    |         | 3               |                |                                                                                    | *KFU               | 40         |
| C≮   | ***     | **              | THIS           | SUB-FROGRAM PERFORMS THE FOLLOWING FUNCTION:                                       | *KFU               | 50         |
| C    |         | 4               |                | 1. COMPUTE THE ENGREMENTED FREQUENCY VALUES FOR THE NEXT                           | *KFU               | 60         |
| С    |         | 4               |                | ANALYSIS.                                                                          | *KFU               | 70         |
| ç    |         | 9               |                |                                                                                    | *KEU               | 63         |
| C*   |         | ₽.≯<br>         | 11115          | SUSTERUGRAMAS ULUSSARY UN FORTRAN NAMES:                                           | *KFU               | 90         |
| E    |         | 9<br>2          |                | I I NUMERA UNUKENENIS (ANALYSIS) UARRIEU UUI<br>Investies                          | ●代刊し -             | 100        |
| 5    |         | ж               |                | 10-20-0-0-0<br>Nervo - 10-20-02 de troite trotournotre                             | ▼Kドワー<br>あり戻し      | 120        |
| ř    |         |                 |                | HERRICH - FRUHLER DE INFOLERCIELLED<br>Søred - I (mante Paristra Paristra Paristra | ▼ 八門 ワー<br>あが 開口 - | 120        |
| ř.   |         | a               |                |                                                                                    | wkE11              | 140        |
| č    |         |                 |                | ALL OTHER MARIAGLE MANES AND ARRAYS AS DEFINED IN                                  | WKEU               | 150        |
| č    |         | e a             |                | EU3-FROERAN ANALY.                                                                 | +KFU               | 160        |
| Ē.   |         |                 |                |                                                                                    | *KFÙ               | 170        |
| 0.0  | ***     |                 | ****           | <b>蔷薇霉霉霉霉霉霉霉霉酮酸酸酸酸酸酸酸酸酸</b> 酸酸化过去就要是我想让我的来找这些这些这些这些这些这些我是能能能                       | *KFU               | 180        |

| С  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | KFU                     | 120            |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|----------------|
|    | COMPLEX PHASE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | KFU                     | 200            |
|    | COMMON 20032 FR(10), AMP(10), FHASE(10), LUNIT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Key                     | 210            |
|    | COMMON /004/ NSTPS(5), FRINC(5), HFR(5)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Kr V                    | 550            |
| _  | 1FLAG=0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | K-Q                     | 230            |
| E. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 10                      | 240            |
| 5. | THE INCREMENT THE INPUT FREQUENCIES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | K-U                     | 200            |
| С  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | KF O                    | 250            |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | KF C                    | 270            |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | KF U                    | 230            |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Kro                     | 250            |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | K-0                     | 200            |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | KEU<br>KEU              | 510            |
|    | IP (IFEHS.EU.U) RETORN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | KEU<br>KEU              | 220            |
| r  | 1-1-1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | NEU<br>NEU              | 520            |
| Ľ. | AND A PRINT THE NEW ERECHENCY HALLES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | K V                     | 5=0            |
| č  | TRANK TRANK THE NEW PREDENCT ONEDED                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 121                     | 520            |
| -  | WRITE (B.115) HINIT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | KEU                     | 570            |
|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | ្រោម                    | 230            |
|    | 110 KRITE (6,120) J.FR(J)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | KFŰ                     | 220            |
|    | RETURN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | KEU                     | 400            |
| С  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | KFU                     | 410            |
| -  | 115 FORMAT (1H1, 18HINPUT FREQUENCIES:,/1H ,SHFREQUENCY, 5X, GHVALUE(, A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 3,KFU                   | 520            |
|    | 11H))                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | KEU                     | 430            |
|    | 120 FORMAT (1H0,4X,11,9X,E10.3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | KFU                     | 440            |
| С  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | KFU                     | 450            |
|    | END                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | KEU                     | 430            |
|    | SUBROUTINE LTRANS (NEG,N1,NADD,KK,NLBN,BR,NFROM,NTO,TYPE,ICONT,U                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ALLTR                   | 10             |
|    | 1UE, NNODE, KEY)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | LTR                     | 20             |
| č  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | LTR                     | 30             |
| C  | 新春春春春春春春秋春秋春秋春秋秋春秋春秋春秋春秋春秋春秋春秋秋秋秋秋春秋秋秋秋春秋秋秋秋                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | AAL IK                  | 40             |
| C  | * THIS SUB-FROGRAM PERFORMS THE FOLLOWING FUNCTIONS:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | *_ !!?                  | 50             |
| 5  | • 1. READ THE BIPULAR TRANSISTUR PARAMETERS SPECIFIED BY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | *1 K<br>*1 KD           | 50             |
| Ě  | The user.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | *<br>*                  | - C U<br>- C U |
| ř  | CHELDEHTE THE COEFFICIENT OF THE NOMETHER ELEMENTS     BERGENT IN THE CONTINUE FOR TRONSTERS MOLEN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | n 1 N                   | - C0           |
| ř  | * 3 ROM TODILOG DECENTION APPLYS DASTA ON THE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 49 T.D                  | 100            |
| ř  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 50 TR                   | ::0            |
| ř  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | \$TR                    | 120            |
| č  | ****** THIS SUB-PROGRAMAS GUDSSERY OF FORTRAN NAMES:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | *172                    | 120            |
| ē  | * NEG : USER SPECIFIED ELEMENT(DEVICE) NUMBER                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | *LTR                    | 140            |
| č  | * N1 : NOTE NUMBER FOR THE BASE TERMINAL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | *LTR                    | 120            |
| Ĉ  | * NADD : CURRENT HIGHEST BRANCH NUMBER IN THE LINEAR                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | *LTR                    | 160            |
| Ċ  | * NETWORK                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | *LĩR                    | 170            |
| С  | * KK : UPON ENTRANCE: CURRENT NUMBER OF NONLINEAR                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | +°LTR                   | 180            |
| C  | ELEMENTS: UPON EXIT: NUMBER OF NONLINEAR                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | *LTR                    | 190            |
| С  | ELEMENTS AFTER INCLUSION OF TRANSISTOR NON-                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | #LTR                    | 200            |
| С  | + LINEAR ELEMENTS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <ul> <li>LTR</li> </ul> | 210            |
| C  | • ALL DTHER VARIABLE NAMES AND ARRAYS AS DEFINED IN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | *_TR                    | 520            |
| ç  | * SUB-FROGRAM AMAIN.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | *_ TR                   | 520            |
| č  | *                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | *LTR                    | L40            |
| 5  | 븮<br>슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻슻                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | HRRE() (문<br>신문)        | 1220           |
| С  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | LIR                     | 230            |
|    | INTEGER DRETTERRET<br>Deal telteltenay no mi no mo ny ru                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                         | 5.50           |
|    | REMELLETIGTURINTHUTHETHETHETHETHETHETHETHETHETHETHETHETHET                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 1010<br>1010<br>1010    | 200            |
|    | TITLE REPORT DATE AND AN AND A |                         | 500            |
|    | COMMON ZODIZ NIYEZ(10).A(10.9)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | ΓTP                     | 0.01           |
|    | COMMON /016/ NCONT(32), JCONT(10)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | LTR                     | 220            |

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| _   | COMMON ZENOSZ NCAP, NDVS, NRES, NIND, NDCS, NCS<br>DATA R, C, NR, NC, NDZ2H R, 2H C, 2HNR, 2HNC, 2HNDZ | LTR<br>LTR | <b>330</b><br>340 |
|-----|--------------------------------------------------------------------------------------------------------|------------|-------------------|
| ີ C | **** NODE NUMBERS FOR EMITTER. COLLECTOR. AND INTERNAL . MUNCTION                                      |            | 350<br>350        |
| č   |                                                                                                        | LTR        | 370               |
|     | NS=N1+3                                                                                                | LTR        | 380               |
|     |                                                                                                        | LTR        | 390               |
| r   | 1/1=1/1+1                                                                                              |            | 400               |
| Č,  | ***** READ TRANSISTOR PARAMETERS                                                                       | LTR        | 420               |
| Ĉ   |                                                                                                        | LTR        | 430               |
|     | READ (5,120) N, UCB. UCBO, MU, IC, ICMAX, AP, HFEMAX                                                   | LTR        | 440               |
| ~   | READ (5,120) K,REF,EJE,CP2,RB,RC,C1,C3                                                                 |            | 450               |
|     | THE FUTTER RESISTIVE NON INFARITY                                                                      |            | 460               |
| č   |                                                                                                        | LTR        | 480               |
| _   | NADD=NADD+1                                                                                            | LTR        | 490               |
|     | ER(NABD)=NADD                                                                                          | LTR        | 500               |
|     | NLEN(KK)=NADD                                                                                          |            | 510               |
|     | ארי מעמת את את אור איז און                                         |            | 530               |
|     | TYPE(NADD)=NR                                                                                          | LTR        | 540               |
|     | HFE=HFEMAX/(1.00+AP*((ALOS10(IC/ICMAX))**2))                                                           | LTR        | 550               |
|     | IE=IC*(1.00+1.00/HFE)                                                                                  | LTR        | 560               |
|     | G1=37.5*1E                                                                                             |            | 5/0               |
|     | A(KX,2)=01**2/TE/2.00000                                                                               |            | 590               |
|     | A(KK, 3)=G1**3/IE**2/6.00000                                                                           | LTR        | 600               |
| С   |                                                                                                        | LTR        | 610               |
| C I | ***** COLLECTOR DEPENDENT NONLINEARITY                                                                 | LTR        | 620               |
| E   |                                                                                                        |            | E30               |
|     | M1=N+UCB+#(N-1)+M0+#2/UCB0##N                                                                          |            | 650               |
|     | M2=(N-1.0000)*M1/VCB/2.00+M1**2/M0                                                                     | LTR        | 660               |
|     | DUN1=2.00*M2*((N-1.0000)/2.00/VCB+2.0*M1/M0)/3.0000                                                    | LTR        | 670               |
|     | DUM2=M1*((N-1.0000)/2.00/UCB**2+(M1/M0)**2)/3.000                                                      | LTR        | 680               |
|     | M1→1C+M1 /M0                                                                                           |            | 200               |
|     | SN2=IE+N2/M0                                                                                           | LTR        | 710               |
|     | 5H3=IC*M3/M0                                                                                           | LTR        | 720               |
|     | DUM2=ALOG10(2.718281828)*2.000*AP                                                                      | LTR        | 730               |
|     |                                                                                                        |            | 740               |
|     | A2=~A1##7*NUM2#(NUM1+A) NG1N(2,718281818))/2,0/IC/HFEMAX                                               |            | 760               |
|     | A3=(A1/6.00)*(-2.00*A2/IC+12.00*(A2/A1)**2-A1**3*DUM2**2/2.00/AP/                                      | ILTR       | 770               |
|     | 1C**2/HFEMAX)                                                                                          | LTR        | 780               |
|     | JJ=KK+1                                                                                                | LTR        | 790               |
|     |                                                                                                        |            | 800               |
|     | BR(NADD)=NADD                                                                                          | ITR        | 820               |
|     | NFROM(NADD)=NCJ                                                                                        | LTR        | 830               |
|     | LN=(CCAN)OTN                                                                                           | LTR        | 840               |
|     | TYPE(NADD)=ND                                                                                          | LTR        | 850               |
|     | 10011 (TRUD)=PADD+1<br>PCONT(_1)=NADD+1                                                                |            | 820               |
|     | A(_LL_1)=A(+MB+A(KK_1))                                                                                | LTR        | 880               |
|     | A(JJ,2)=SM1                                                                                            | LTR        | 890               |
|     | A(JJ,3)=A2#M0*A(KK,1)##2+A1#M0*A(KK,2)                                                                 | LTR        | 900               |
|     |                                                                                                        |            | 910               |
|     | 이 나는 다 그 가 주 이 나 주 나 다 주 이 나 다 다 가 가 가 가 다 다 가 가 다 다 가 가 다 다 다 다 다                                     | 1 1 1 1    | acu               |

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| A(JJ,6)=A3*M0*A(KK,1)**3+A1*M0*A(KK,3)+2.0*A2*M0*A(KK,1)*A(KK, | 2) LTR 930 |
|----------------------------------------------------------------|------------|
| A(JJ,7)=SM3                                                    | LTR S40    |
| A(JJ,8)=A2*M1*A(KK,1)**2+A1*M1*A(KK,2)                         | LTR S50    |
|                                                                | LIR SSU    |
| L CARAGE COLLECTOR-ROSE COROCITANCE                            | LTR 570    |
|                                                                | LIK 200    |
| NADD=NADD+1                                                    | LTR 1000   |
|                                                                | LTR 1010   |
| NFROM(NADD)=NCJ                                                | LTR 1020   |
| NTO(NADD)=N1                                                   | LTR 1030   |
| IF (ABS(C3).EQ.0.0000000) GD TO 105                            | LTR 1040   |
| TYPE(NADD)=C                                                   | LTR 1050   |
| VALUE(NADD)=C3                                                 | LTR 1060   |
| KEY(NADD)=2                                                    | LTR 1070   |
| NCAP=NCAP+1                                                    | LTR 1080   |
|                                                                | LIR 1090   |
| $\frac{105}{100} OHCUC(1000) = 0$                              | LIR 1100   |
|                                                                | LTR 1120   |
| NRFS=NRFS+1                                                    | LTR 1120   |
|                                                                | LTR 1140   |
| CARARA EMITTER CAPACITOR(LINEAR)                               | LTR 1150   |
| C                                                              | LTR 1160   |
| 110 NADD=NADD+1                                                | LTR 1170   |
| BR(NADD)=NADD                                                  | LTR 1180   |
|                                                                | LIR 1150   |
|                                                                | LIR 1200   |
|                                                                | LTR 1210   |
|                                                                | LTR 1230   |
| NCAP=NCAP+1                                                    | LTR 1240   |
| C                                                              | LTR 1250   |
| C##### BASE-EMITTER CAPACITANCE(LINEAR)                        | LTR 1260   |
| с                                                              | LTR 1270   |
| IF (ABS(CI).EQ.0.000) GO TO 115                                | LTR 1280   |
|                                                                | LIR 1290   |
| BR(1HDJ)-N                                                     | LIR 1300   |
|                                                                | LTR 1310   |
| TYPE(NADD)=C                                                   | LTR 1330   |
| VALUE(NADD)=C1                                                 | LTR 1340   |
| KEY(NADD)=2                                                    | LTR 1350   |
| NCAP=NCAP+1                                                    | LTR 1360   |
| C                                                              | LTR 1370   |
| C+++++ COLLECTOR CAPACITIVE NONLINEARITY                       | LTR 1380   |
|                                                                | LTR 1390   |
|                                                                | LIR 1400   |
| ארעראו-בעראו<br>אראס אראס אראס אראס אראס אראס אראס אראס        | LTR 1410   |
|                                                                | LTR 1420   |
|                                                                | LTR 1440   |
| TYPE(NADD)=NC                                                  | LTR 1450   |
| NLBN(LL)=NADD                                                  | LTR 1460   |
| A(LL,1)=K/UCB**MU                                              | LTR 1470   |
| A(LL,2)=-A(LL,1)/UCB/6.000                                     | LTR 1480   |
| A(LL,3)=A(LL,1)/UCB**2/27.00                                   | LTR 1490   |
|                                                                | LTR 1500   |
| C                                                              | LIK 1510   |
| ••                                                             |            |

LTR 1530 LTR 1540 LTR 1550 NABE=NABE+1 NABD=NADD+1 ERINADD:=NADD NERCH(NADD:=NSU NYDI(NADD)=NJ YYFE(NADD)=RJ YYFE(NADD)=R KEY(NADD)=5 NRES=NRES+1 LTR 1550 LTR 1570 LTR 1580 LTR 1590 LTR 1600 LTR 1610 С C\*\*\*\*\* UNEE REDECTANCE(LINEAR) LTR 1620 LTR 1630 ē DR(NE3)=NEG NFRG((NEG)=N1 NFG(NEG)=NJ TYPE(NEG)=R NFE(NEG)=P3 NEG(NEG)=5 NFEG=NRES+1 LTR 1640 LTR 1650 LTR 1650 LTR 1670 LTR 1680 LTR 1680 LTR 1700 LTR 1710 С LTR 1710 LTR 1720 LTR 1730 LTR 1740 LTR 1750 LTR 1750 LTR 1770 LTR 1770 KK=KK+2 MNODE=MAMO(NNODE+NE) C C\*\*\*\*\* URITE TRANSISTOR PARAMETERS С WRITE (6,125) N,UCB,UCDD,MU WRITE (6,130) XC, XCMAX, 67, HFEMAX WRITE (6,135) K-REF,CJE,CP2 WRITE (6,135) K-REF,CJE,CP2 MRITE (6,140) RB,RC,C1,C3 RETURN LTR 1780 LTR 1780 LTR 1790 LTR 1800 LTR 1810 LTR 1820 С 12.3) 140 FORMAT (1H ,SHR3=,F3.3,SK,SHRC=,E12.3,SK,SHC1=,E12.3,SK,SHC3=,E12.LTR 1830 12+/2/100 LTR 1910 С LTR 1520 END LTR 1930

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## 5-4. System Dependent Cards

Program PRANC was developed on the CDC 6500/6600 computer system at Purdue University. The system dependent cards contained in the program are listed in Table 5-1. A NUMBER OF STREET

Table 5-1. System Dependent Cards

| Sub-Program | Card I | dentification Number |
|-------------|--------|----------------------|
| AMAIN       | AMN    | 2200,6000,6430       |
| GZOC        | GZC    | 380                  |
| JSEP        | JSP    | 230,250              |

The sub-programs, and their functions called by the cards listed in Table 5-1 are as follows:

<u>SECOND</u>: Subroutine SECOND is used to determine the elapsed time in seconds in performing a sequence of PRANC phrases.

LINEQ4: Subroutine LINEQ4 is a linear equation solver routine, used to invert a complex matrix.

ISHFTLA (I,N): is used to perform an N-place arithmetic left shift on I (circular).

ISHFTRA (I,N): is used to perform an N-place arithmetic right shift on I (end-off, sign fill); e.g. K = ISHFTRA (1,1) sets K to 0; K = ISHFTRA (1,0) sets K to 1.

### CHAPTER 6

#### CONCLUDING REMARKS

As stated earlier, the fundamental objective underlying this research effort was to examine the computational aspect of the Volterra series method. In the process, we developed an efficient algorithm for adapting the Volterra series method for computer-aided analysis of nonlinear circuits. A semi-symbolic approach for analyzing the linearized part of the nonlinear circuit was used as the basis for this development. The algorithm was implemented in a computer program, entitled PRANC. The main contributions of this effort may thus be identified as follows:

- (1) The development of an efficient algorithm for adapting the Volterra series method for computer-aided analysis.
- (2) The development of a symbolic approach for analyzing the linearized circuit.
- (3) The development of a digital computer program for the spectrum analysis of nonlinear circuits.

As part of the effort, several network examples were exercised on PRANC. The execution times involved in these examples indicate that PRANC is highly efficient from a computational standpoint. Networks with several nonlinearities, several energy storage elements (as in Example 4-2), and multiple input frequencies involve execution times which are small and easily affordable.

The fundamental criterion in the development of PRANC was computational efficiency. The results from the use of PRANC indicate that this criterion

has been met successfully. The "ease of use", which is another important performance measure in software development, was not given as much weight in this effort. As part of continuing work, it is recommended that several user-oriented features, such as free-format input, built-in device modelling, parameter variation feature, etc., be incorporated in the program. The computational efficiency inherent in the present version of PRANC together with certain "ease of use" features should render it a powerful tool for analyzing nonlinear circuits.

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# Appendix A. A DEVICE MODELLING EXAMPLE

In this section we present an example of how to obtain mathematical models for nonlinear devices. The mathematical models so developed can then be used to obtain equivalent circuits for analysis purposes.

Most devices commonly encountered in electronics, where one would be interested in computing the harmonic distortion due to the nonlinear operation, are operated in the active region where the device operation is quasi-linear about an operating point established by the circuit bias. Here we develop the incremental model for some such devices. It is important to make a distinction between total and incremental nonlinear circuits. Total model, or global models, interrelate the total instantaneous voltages, current, and/or charges in the device. Such models are used for operating point or large-signal analysis. The incremental or small-signal models for devices are derived from these global models by some kind of an approximation (usually a Taylor series expansion) around the operating point. In deriving incremental models, it is desirable to have a model that is independent of the bias point in the normal active region, so that the nonlinear effects due to a change in the operating point can be predicted.

We now present a mathematical model for a semiconductor diode. In the commonly used small-signal applications of semiconductor diodes, two types of operations are encountered: (1) forward-bias (e.g. mixers); (2) reversebias (varactor converter).

In the forward-bias operation, the primary nonlinearity is a memoryless nonlinearity given by

$$I = I_{cexp}(qV/nkT) - 1]$$

(1)

where n is the ideality factor for the diode. Then for the forward-biased diode with a small-signal input, we can write eqn. (1) as:

$$I_{D} + i_{d} = I_{S} [exp(qV_{D}/nkt)exp(qV_{d}/nkT) - 1]$$
 (2)

where  $I_D$  and  $V_D$  are the bias current and voltage, respectively, and  $i_d$  and  $v_d$  are the incremental current and voltage. For  $(qv_d/nkT) < 1$ , we have a convergent Taylor series for:

$$\exp(qv_d/nkT) = \sum_{s=0}^{\infty} \frac{1}{s!} \left(\frac{qv_d}{nkt}\right)^s$$
(3)

Substituting (3) into (2) and approximating

$$I_{D} = I_{S} \left[ exp \frac{qV_{D}}{nkT} - 1 \right] \approx I_{S} exp \frac{qV_{D}}{nkT},$$

we obtain the following:

$$\dot{v}_{D} = I_{D} \frac{q}{nkT} v_{d} + \frac{I_{D}}{2!} \frac{q}{nkT}^{2} v_{d}^{2} + \frac{I_{D}}{3!} \frac{q}{nkT}^{3} v_{d}^{3} + \dots$$
(4)

which is in a form suitable for analysis on PRANC.

In the case of the reverse-biased diode, the primary nonlinearity is the nonlinear junction capacitance C(V), where C(V) is of the following form:

$$C(V) = \frac{C(0)}{[1 - V/\phi]^{k}}$$
(5)

where C(0),  $\phi$ , and k are generally specified by the manufacturer.

The charge stored in the capacitor of eqn. (5) is:

$$Q(V) = \int_{0}^{V} C(V) \, dV$$
  
=  $\frac{\phi}{(k-1)} \frac{C(0)}{[1 - V/\phi]^{(k-1)}}$  (6)

Expanding eqn. (6) into a Taylor series yields:

$$Q(V_{c} + v_{c}) = C(V_{c}) \left[ \frac{(\phi - V_{c})}{(k-1)} + v_{c} + \frac{kv_{c}^{2}}{2!(\phi - V_{c})} + \frac{k(k+1)v_{c}^{3}}{3!(\phi - V_{c})^{2}} + \dots \right]$$
(7)

The incremental capacitor current is the change of total charge with respect to time. Since V is a constant, we get

$$i_{c} = \frac{dQ}{dt} = C(V_{c}) \frac{dv_{c}}{dt} + \frac{kC(V_{c})}{2!(\phi - V_{c})} \frac{dv_{c}^{2}}{dt} + \frac{k(k+1)C(V_{c})}{3!(\phi - V_{c})^{2}} \frac{d}{dt} v_{c}^{3} + \dots (8)$$

Equation (8) is the mathematical model of the incremental nonlinear capacitance current. The first term is a linear capacitor of value  $C(V_c)$ , and the term in  $v_c^n$  represent the nonlinear capacitive terms. Again, note that eqn. (8) is in a form suitable for analysis on PRANC.

The models for other nonlinear devices, such as transistors, JFETS, vacuum tubes, etc., can be found using the same kind of an approach.

